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Canadian Journal of Zoology

*Issued by* THE NATIONAL RESEARCH COUNCIL OF CANADA

VOLUME 29 APRIL, 1951 NUMBER 2

# NUTRITION DES LARVES DE *TRIBOLIUM CONFUSUM* DUVAL

## I. RECHERCHE D'UN RÉGIME SYNTHÉTIQUE BASAL SATISFAISANT LEURS BESOINS NUTRITIFS[1]

PAR A. LEMONDE[2] ET R. BERNARD[3]

## Abstract

A purified diet suitable for the study of the qualitative amino acids requirements of the larvae of the Coleoptera *Tribolium confusum* is presented. The composition of the diet is as follows: amino acid mixture 20%, cornstarch 75.5%, cholesterol 1%, wheat germ oil 1.5%, salt mixture No. 2 U.S.P. XII 2%, yeast 0.5%, vitamin mixture M.V.–II. In presence of amino acids, glucose cannot be used as a source of hydrocarbon. The mixture is very hygroscopic, develops a brown color, and is apparently toxic to the larvae. The importance of choline as a growth factor is demonstrated. Wilson's Liver Fraction L or Liver Concentrate 1 : 20 cannot replace this vitamin. Yeast appears to contain unknown factors for it improves growth when added to a diet already supplemented with vitamins known to be essential for the larvae. A mixture of 19 crystalline amino acids known to occur in casein satisfies the nitrogen requirements of the larvae of *T. confusum* equally as well as purified casein.

## Introduction

Avant d'étudier la valeur des acides aminés dans l'alimentation des larves de *T. confusum*, nous croyons nécessaire de définir un régime basal qui satisfasse entièrement les exigences nutritives de ces larves. Plusieurs chercheurs dont Chapman (4), Sweetman et Palmer (18), Chiu et McCay (5), Fröbrich (13), Offhaus (15), Barton-Wright (1), Rosenthal et Reichstein (17) ont proposé des régimes de base pour étudier les besoins nutritifs de cet insecte. La plupart de ces régimes avaient, à peu de chose près, la composition suivante: caséine 15 à 20%, amidon de riz ou de maïs 75%, lipides 1 à 5%, levure 1 à 5%, sels 3 à 5%.

Au cours de travaux sur la nutrition de plusieurs espèces d'insectes, Fraenkel et Blewett (8) ont déterminé le régime suivant: caséine 45%, glucose ou amidon 45%, huile de germe de blé 0 ou 0.5%, cholestérol 1%, levure 5%, mélange salin de McCollum 1%. Ces chercheurs, à l'encontre de tous leurs collègues, ont élevé à 45 le pourcentage de caséine pour s'assurer disent-ils, d'une fraction protéique suffisante. Avec ce régime, ils ont démontré que, si les glucides ne sont pas essentiels dans la nutrition des larves de *T. confusum*,

[1] *Manuscrit reçu le 16 octobre 1950.*

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leur présence est toutefois avantageuse. Parmi les glucides qu'ils ont employé, l'amidon favorisait une croissance maximum et le glucose venait ensuite. Récemment Bernard et Lemonde (2) ont nommé 16 espèces de sucres pouvant satisfaire les exigences glucidiques des larves de cet insecte. Parmi ceux-ci, le saccharose et l'amidon se sont avérés les plus efficaces.

Fraenkel et Blewett (7, 9) ont aussi recherché les exigences de plusieurs insectes pour les vitamines du complexe B. Ils ont précisé les quantités minima requises par les larves de *T. confusum* (6, 9). Nous les reproduisons en milligrammes par 100 grammes de régime: aneurine 0.1, riboflavine 0.1 à 0.2, acide nicotinique 0.8 à 1.6, pyridoxine 0.05 à 0.1, acide pantothénique 0.4, biotine 0.005, acide folique 0.0125. A ce mélange ils ajoutent 50 milligrammes de choline car l'absence de cette vitamine retarde la croissance (7).

A l'aide de toutes ces données antérieures, nous avons poursuivi une série d'expériences pour composer un régime synthétique basal qui nous permît d'étudier les besoins en acides aminés des larves de ce Coléoptère.

## Méthodes Expérimentales

La majorité des régimes utilisés au cours de nos expériences se composent d'ingrédients chimiquement purs. La fabrication des régimes se poursuit généralement de la façon suivante. Nous mêlons le plus parfaitement possible les constituants azotés, le mélange salin et le glucide. Puis l'huile de germe de blé et le cholestérol sont ajoutés tels quels. Nous ajoutons ensuite les vitamines en solution aqueuse. Après dessiccation, nous broyons et mélangeons une dernière fois les ingrédients de façon à obtenir un milieu parfaitement homogène.

Les larves de *T. confusum* que nous utilisons proviennent de cultures constamment renouvelées depuis trois ans. Pour les besoins des expériences, nous tâchons de prélever des larves les plus jeunes possible, presque au moment de leur éclosion afin d'avoir des sujets à peu près tous du même âge. Pour chacun des régimes mis à l'essai, nous prélevons trente larves, divisées en trois lots de dix larves chacun. Ces larves sont déposées dans des bouteilles de deux pouces et demi de hauteur par un pouce de diamètre. Elles contiennent de deux à trois grammes de régime. Cette quantité de régime est satisfaisante pour toute la durée de l'expérience qui se limite généralement à cent jours. Au bout de ce temps, si la croissance est nulle, nous considérons le régime comme impropre pour assurer la nutrition des larves de *T. confusum*.

Les bouteilles sont rangées dans une étuve où la température est maintenue à 28 $\pm$ 1° C. L'humidité relative est maintenue à 70 $\pm$ 5% au moyen d'un générateur de vapeur* et d'un humidistat à cheveux.

* *Aminco Steam-Generating Humidifier, American Instrument Company, Silver Spring, Maryland.*

Pour juger de la valeur nutritive des régimes, le meilleur critérium, selon Chapman (4), est la durée du stade larvaire ou le temps que mettent les larves à puper. Nous procédons au décompte des larves une à deux fois par semaine au début de l'expérience. Puis, dès l'apparition de la première pupe, nous visitons les bouteilles presque tous les jours. Nous présentons généralement les résultats de la façon suivante: Après avoir donné le nombre total de larves qui ont pupé et les temps limites requis pour accomplir cette métamorphose, nous calculons la période moyenne de pupaison en jours et son erreur normale. Le nombre exprimant cette période est obtenu au moyen de la formule suivante: $M = \frac{\Sigma fm}{N}$.

$M$ = période moyenne de pupaison en jours.

$f$ = nombre de pupes le nième jour de l'expérience.

$m$ = le nième jour de l'expérience.

$N$ = nombre total de pupes à la fin de l'expérience.

## Protocole Expérimental

Nous avons utilisé au cours de nos expériences trois régimes de base exposés dans le Tableau I. Toute addition à ces régimes a été faite aux dépens de la fraction glucidique représentée par le glucose, l'amidon ou le saccharose. Nous avons ajouté les vitamines, soit sous forme de cinq pour cent de levure de bière desséchée, soit sous forme de l'un des mélanges vitaminiques détaillés dans le Tableau I. Ces deux mélanges ne diffèrent que par la présence de choline dans le second (M.V.-II). A cette vitamine nous avons substitué tour à tour, deux extraits de foie. Un premier est connu sous le nom de "Wilson's Liver Fraction L"* et le deuxième est un concentré de foie entier 1 : 20.**

Nous donnons dans le Tableau II la composition des mélanges d'acides aminés mis à l'essai. Les quantités d'aminoacides contenus dans le premier mélange (A.A.-I) sont basées sur le pourcentage de ces aminoacides naturels dans la caséine d'après Block et Bolling (3). Le second mélange (A.A.-II) est en tout point semblable à celui qui a été composé par Rose (16) dans ses travaux sur la détermination des acides aminés essentiels au rat.

La fabrication des mélanges se poursuit de la façon suivante. Nous pesons les quantités d'acides aminés, puis nous les mélangeons dans un moulin à billes que nous laissons tourner durant quelques heures. Ce brassage et ce broyage nous assurent d'une homogénéité satisfaisante.

* *Source des vitamines inconnues du complexe B. Wilson Laboratories, Chicago, Ill.*

** *Liver Extract Concentrate 1 : 20. Nutritional Biochemicals Corporation, Cleveland, Ohio.*

TABLEAU I

COMPOSITION DES RÉGIMES DE BASE UTILISÉS DANS LA RECHERCHE D'UN RÉGIME SYNTHÉTIQUE SATISFAISANT LES BESOINS NUTRITIFS DES LARVES DE *T. confusum*

*Principaux ingrédients*

| Ingrédients | Numéro des régimes de base | | |
|---|---|---|---|
| | R-1 | R-2 | R-3 |
| | Composition | | |
| | % | | |
| Caséine | 20.0 | 40.5 | 50.0 |
| Glucide | 75.5 | 55.0 | 45.5 |
| Cholestérol | 1.0 | 1.0 | 1.0 |
| Huile de germe de blé | 1.5 | 1.5 | 1.5 |
| Mélange salin no. 2 USP XII | 2.0 | 2.0 | 2.0 |

*Mélanges de vitamines*

| Vitamines | Numéro des mélanges | |
|---|---|---|
| | M.V.-I | M.V.-II |
| | Composition | |
| | $\mu$ gm. par gm. de régime | |
| Chlorhydrate de thiamine | 1 | 1 |
| Riboflavine | 2 | 2 |
| Chlorhydrate de pyridoxine | 1 | 1 |
| Acide nicotinique | 8 | 8 |
| Pantothénate de calcium | 4 | 4 |
| Biotine | 0.05 | 0.05 |
| Acide ptéroylglutamique | 0.2 | 0.2 |
| Chlorure de choline | — | 500 |

## Résultats et Discussion

Nous avons déjà signalé que la caséine semble suffire aux exigences protéiques des larves de *T. confusum* et que l'un des trois sucres: glucose, saccharose ou amidon, satisfait leurs besoins glucidiques. Au cours de leurs travaux, Fraenkel et Blewett (8), puis Bernard et Lemonde (2) ont régulièrement constaté l'infériorité du glucose par rapport à l'amidon et au saccharose. Étant donné la préférence de notre Coléoptère pour les polyholosides, nous avons cru pouvoir inférer qu'une élévation du taux de glucose corrigerait cette infériorité et permettrait aux larves de s'y développer aussi parfaitement que dans un polyholoside tel que l'amidon. Nous avons donc poursuivi une première série d'expériences, espérant vérifier cet avancé.

TABLEAU II

COMPOSITION DES MÉLANGES D'ACIDES AMINÉS UTILISÉS DANS LA RECHERCHE D'UN RÉGIME SYNTHÉTIQUE SATISFAISANT LES BESOINS NUTRITIFS DES LARVES DE *T. confusum*

| Acides aminés | Formes utilisées | Numéro des mélanges d'acides aminés | | | |
|---|---|---|---|---|---|
| | | A.A.-I | | | A.A.-II* |
| | | % des acides aminés naturels dans la caséine** | Corrections apportées | Gm. par 100 gm. de régime | Gm. par 100 gm. de régime |
| Alpha alanine | DL | 5.6 | 11.2† | 1.42 | 0.49 |
| Arginine | | 4.1 | | | |
| Arginine HCl | L | | 4.5†† | 0.63 | 0.59 |
| Acide aspartique | DL | 6.3 | 12.6† | 1.60 | 0.49 |
| Acide glutamique | L | 22.80 | 22.8 | 2.89 | 2.44 |
| Cystine | L | 0.36 | 1.5††† | 0.19 | 0.24 |
| Glycine | | 0.5 | 1.5††† | 0.19 | 0.12 |
| Histidine | | 2.5 | | | |
| Histidine HCl | L | | 2.8†† | 0.39 | 1.05 |
| Hydroxyproline | L | 2.0 | 2.0 | 0.25 | 0.12 |
| Isoleucine | DL | 6.5 | 13.0† | 1.65 | 1.95 |
| Leucine | L | 12.1 | 12.1 | 1.53 | 1.47 |
| Lysine | | 6.9 | | | |
| Lysine HCl | L | | 7.7†† | 1.08 | 1.83 |
| Méthionine | DL | 3.5 | 7.0† | 0.89 | 0.98 |
| Phénylalanine | DL | 5.2 | 10.4† | 1.32 | 1.47 |
| Proline | L | 8.2 | 8.2 | 1.04 | 0.24 |
| Sérine | DL | 6.0 | 12.0† | 1.52 | 0.24 |
| Thréonine | DL | 3.9 | 7.8† | 0.99 | 1.71 |
| Tryptophane | L | 1.8 | 1.8 | 0.23 | 0.23 |
| Tyrosine | L | 6.4 | 6.4 | 0.81 | 0.73 |
| Valine | DL | 7.0 | 14.0 | 1.77 | 2.44 |
| $NaHCO_3$*** | | | 2.9 | 0.85 | 1.29 |
| Total | | 111.66 | 160.7 | 21.04 | 20.39 |

* *W. C. Rose et al. J. Biol. Chem. 176, 753-62. 1948.*

** *Données tirées de Block et Bolling.*

*** *Ajouté pour parer à l'acidité entraînée par la présence de HCl.*

† *Nous avons doublé les acides aminés racémiques supposant que la forme D n'est pas active.*

†† *Correction due à la présence de HCl.*

††† *Les quantités normales étant très faibles, nous les avons augmentées.*

Tous les résultats obtenus au cours des diverses séries d'expériences sont exposés dans le Tableau III.

Les trois différents taux de saccharose ou d'amidon utilisés ont tous donné des résultats statistiquement identiques à ceux que nous obtenions avec la farine de blé entier. Nous avons observé le même résultat avec le glucose au taux de 75.5%. En effet 26 larves ont pupé dans une période moyenne de 19.3 jours. Lorsque nous avons fourni aux larves 55 ou 40.5% de glucose, nous avons noté un retard significatif dans la croissance. La période moyenne de pupaison est passée de 19.3 à 26 jours. Ce retard n'est certainement pas dû aux forts pourcentages de caséine puisque ces mêmes pourcentages

## TABLEAU III

RÉSULTATS OBTENUS DANS LA RECHERCHE D'UN RÉGIME SYNTHÉTIQUE SATISFAISANT LES BESOINS NUTRITIFS DES LARVES DE *T. confusum*

| Régime basal No. | Additions au régime basal utilisé | Nombre de pupes sur 30 larves | Période moyenne de pupaison en jours $\pm \sigma_m$ | Temps limites de pupaison en jours |
|---|---|---|---|---|
| *Première série d'expériences* | | | | |
| R-1 | Glucose 75.5%, levure 5% | 26 | 19.3 ± 0.35 | 18 – 25 |
| R-1 | Saccharose " , " | 28 | 20.5 ± 0.41 | 18 – 25 |
| R-1 | Amidon " , " | 25 | 21.6 ± 0.35 | 18 – 25 |
| R-2 | Glucose 55.0%, " | 25 | 26.8 ± 0.34 | 25 – 32 |
| R-2 | Saccharose " , " | 27 | 20.3 ± 0.23 | 19 – 22 |
| R-2 | Amidon " , " | 29 | 20.9 ± 0.29 | 18 – 25 |
| R-3 | Glucose 40.5%, " | 26 | 26.3 ± 0.36 | 24 – 31 |
| R-3 | Saccharose " , " | 24 | 19.4 ± 0.38 | 18 – 25 |
| R-3 | Amidon " , " | 24 | 20.6 ± 0.25 | 18 – 22 |
| *Deuxième série d'expériences* | | | | |
| R-1 | Glucose 75.5%, vitamines M.V.-I | 27 | 35.9 ± 0.78 | 28 – 42 |
| R-1 | " " , M.V.-I, WLFL* 0.5% | 26 | 29.1 ± 0.32 | 27 – 34 |
| R-1 | " " , " , CF** 1 : 20 0.5% | 24 | 31.1 ± 0.56 | 28 – 38 |
| R-1 | " " , vitamines M.V.-II | 29 | 25.2 ± 0.38 | 21 – 28 |
| R-1 | " " , " " | 26 | 25.4 ± 0.42 | 22 – 30 |
| *Troisième série d'expériences* | | | | |
| R-1 | Amidon 75.5%, M.V.-II, levure 0.3% | 26 | 23.5 ± 0.33 | 21 – 27 |
| R-1 | " " , " , levure 0.5% | 29 | 23.0 ± 0.53 | 21 – 28 |
| R-1 | " " , " , levure 1% | 28 | 22.0 ± 0.46 | 20 – 28 |
| R-1 | " " , " , WLFL 0.5% | 28 | 26.5 ± 0.36 | 25 – 33 |
| R-1 | " " , " , CF 1 : 20 0.5% | 23 | 25.1 ± 0.32 | 22 – 29 |
| *Quatrième série d'expériences. Substitution des mélanges d'acides aminés à la caséine* | | | | |
| R-1 | Glucose 75.5%, M.V.-II, A.A.-I | — | — | — |
| R-1 | Glucose 75.5%, M.V.-II, A.A.-II | — | — | — |
| R-1 | Amidon 75.5%, M.V.-II, A.A.-I | 22 | 37.0 ± 1.01 | 30 – 45 |
| R-1 | " " , " , A.A.-II | 24 | 32.7 ± 0.94 | 26 – 41 |
| R-1 | " " , " , A.A.-II, levure 1% | 18 | 24.5 ± 0.60 | 21 – 30 |
| R-1 | " " , " , A.A.-II, levure 0.5% | 28 | 22.2 ± 0.41 | 20 – 26 |
| R-1 | " " , " , A.A.-II, levure 0.3% | 26 | 22.0 ± 0.31 | 20 – 24 |
| R-1 | " " , " , A.A.-II, WLFL 0.5% | 23 | 30.0 ± 0.73 | 26 – 38 |
| R-1 | " " , " , A.A.-II, CF 1 : 20 0.5% | 26 | 29.8 ± 0.50 | 25 – 37 |
| Farine de blé entier (régime naturel) | | 29 | 19.0 ± 0.10 | 18 – 20 |

* *WLFL: "Wilson's liver fraction L".*

** *CF 1 : 20, concentré de foie 1 dans 20.*

ont donné des résultats excellents avec la saccharose et l'amidon. Nous croyons plutôt que les larves de *T. confusum* satisfont mieux leurs besoins glucidiques avec le saccharose et l'amidon qu'avec le glucose. De plus, *T. confusum* est un parasite important des farines et l'aliment idéal pour le cultiver est la farine de blé entier. Or la fraction glucidique de cette farine s'élève à 68% et sa fraction protéique n'atteint que 15 à 16%. Il ne faut donc pas se surprendre si un régime constitué en parties égales de protéines et de glucides se montre inférieur à un autre dont la composition se rapproche beaucoup de celle de la farine de blé entier.

Dans une deuxième série d'expériences, nous avons substitué des mélanges de vitamines (Tableau I) à la levure. Les résultats observés avec le mélange I, qui ne contient pas de choline, ont confirmé ceux qu'avaient déjà obtenus Fraenkel et Blewett (7). Ces chercheurs ont en effet démontré que l'absence de choline apporte un retard appréciable dans la croissance des larves de *T. confusum*. Si, à ce mélange, nous octroyons l'extrait de foie "Wilson's Liver Fraction L" ou le concentré de foie 1 : 20, les résultats sont sensiblement améliorés. Toutefois ni l'un ni l'autre de ces deux extraits de foie ne peut remplacer la choline présente dans le mélange II de vitamines. Avec ce mélange, additionné de glucose ou d'amidon, nous avons obtenus des résultats beaucoup plus satisfaisants, mais non encore égaux à ceux qui avaient été réalisés avec la levure comme source vitaminique.

Apparemment, en outre des facteurs déjà connus, la levure en contiendrait un ou plusieurs autres, nécessaires aux larves de *T. confusum*. Ceci confirme l'hypothèse déjà formulée par deux groupes différents de chercheurs. Grob, Rosenthal et Reichstein (14) puis Fraenkel et Blewett (9, 10) ont signalé la nécessité, pour cet insecte, d'un autre facteur indéterminé contenu dans la fraction non hydrosoluble de la levure.

Nous avons donc poursuivi une troisième série d'expériences pour déterminer ce qu'il nous fallait ajouter aux régimes pour fournir aux larves ce ou ces facteurs indéterminés. Des taux de levure variant de 0.3 à 1.0% ont tous donné d'excellents résultats. La période moyenne de pupaison s'est en effet située entre 22 et 23.5 jours. Nous ne croyons pas que l'addition d'un si faible pourcentage de levure constitue une source azotée assez appréciable pour nous empêcher de dépister les acides aminés essentiels chez les larves de ce Coléoptère.

L'extrait de foie "Liver Fraction L" et le concentré de foie 1 : 20 ne contiennent pas ce ou ces facteurs inconnus. Les données acquises avec ces deux ingrédients ont été semblables à celles que nous avaient fournies le mélange II de vitamines (deuxième série d'expériences).

Dans une quatrième série d'expériences, nous avons remplaçé la caséine par des mélanges de 19 acides aminés. Utilisé avec le glucose, ni l'un ni l'autre des deux mélanges n'a été satisfaisant. Les régimes sont devenus brun foncé et très hygroscopiques. Toutes les larves y sont mortes très rapidement, probablement à cause de la grande hygroscopicité des régimes

ou des produits toxiques qui s'y seraient formés. Des travaux récemment publiés sur la réaction entre acides aminés et sucres, réaction dite de Maillard, nous semblent expliquer, du moins partiellement, la nocivité de ces régimes (11, 12). La substitution de l'amidon au glucose élimine le brunissement et rend l'hygroscopicité négligeable.

Le mélange II d'acides aminés nous a donné de meilleurs résultats que le mélange I. Ces résultats sont cependant inférieurs à ceux que la caséine avait produits (deuxième série d'expérience). L'octroi de l'un ou l'autre des deux extraits de foie n'améliore aucunement les résultats. La période moyenne de croissance demeure aux environs de 30 jours. Par contre, l'addition de levure a produit une amélioration très sensible: avec 0.5% de levure, 28 larves ont pupé dans une période moyenne de 22 jours. C'est là un résultat identique à celui que nous avons observé en employant la caséine comme source azotée.

Il est donc possible de remplacer la caséine par un mélange d'acides aminés et les larves de *T. confusum* y croissent normalement. Toutefois les résultats demeurent légèrement inférieurs à ceux qu'on obtient avec la farine de blé entier. En ceci, *T. confusum* se comporte comme la plupart des animaux: les régimes naturels sont souvent légèrement supérieurs aux régimes artificiels.

A la suite de ces recherches préliminaires, nous nous proposons d'étudier les besoins qualitatifs en acides aminés de *T. confusum* à l'aide d'un régime purifié ayant la composition suivante: mélange d'acides aminés A.A.-II 20%, amidon de maïs 75.5%, cholestérol 1%, huile de germe de blé 1.5%, mélange salin no. 2 U.S.P. XII 2% et mélange de vitamines M.V.-II.

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# NUTRITION DES LARVES DE *TRIBOLIUM CONFUSUM* DUVAL

## II. IMPORTANCE DES ACIDES AMINES[1]

PAR A. LEMONDE[2] ET R. BERNARD[3]


### Abstract

The normal pupation period of *Tribolium confusum* on whole wheat diet averages 18 days. In presence of a purified diet containing 19 crystalline amino acids known to exist in casein, the pupation period is increased to 28 days. Removal of one of the amino acids considered as nonessential for growth in the rat from such a diet, results in pupation periods falling between 26 and 32 days. On the other hand, omission of lysine, threonine, phenylalanine, methionine, isoleucine, and arginine, one at a time, increases the pupation period from 61 to 70 days. If valine, tryptophane, histidine, or leucine are left out singly, pupation is prevented, though two-thirds of the larvae survive. It is concluded that the amino acids known to be essential for growth in the rat are also essential for growth and pupation of the larvae of *T. confusum*. Four of these essential amino acids appear to be connected with the phenomenon of pupation.


### Introduction

La nutrition azotée des insectes offre un champ de recherches très vaste et cependant quelques chercheurs seulement s'y sont aventurés. Trager (10), en 1947, nous a présenté une revue détaillée des résultats déjà obtenus dans ce domaine. Il terminait son exposé en disant: "Il est indubitable que les besoins en acides aminés chez les insectes présentent un champ libre et fertile à tout chercheur avide de scruter les secrets de la Physiologie comparée".

Depuis 1947, d'autres travaux ont été publiés. Golberg et DeMeillon (3) ont déterminé 10 acides aminés essentiels aux larves de *Aedes aegypti*. Leclercq (6), utilisant la zéine et la gliadine comme source azotée, a démontré l'importance de la lysine et du tryptophane pour les larves de *Tenebrio molitor*. House (4) a défini cinq acides aminés indispensables chez *Blattella germanica* élevé aseptiquement. Le seul travail paru sur les besoins en acides aminés de *Tribolium confusum*, est celui de Fraenkel (2). Ce chercheur, dans une note préliminaire, a communiqué quelques données sur l'importance de la lysine et du tryptophane dans la nutrition des larves de cet insecte.

Tous ces travaux semblent indiquer que les insectes, à l'instar des mammifères et des espèces aviaires, ont besoin d'acides aminés pour croître et se développer normalement. Quels sont ceux qui s'avèrent essentiels pour les larves de *T. confusum?* Voilà l'objet du présent travail.

### Protocole expérimental

La composition du régime de base utilisé au cours de cette expérience est exposée dans le Tableau I.

[1] *Manuscrit reçu le 16 octobre 1950.*

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TABLEAU I

COMPOSITION DU RÉGIME DE BASE UTILISÉ DANS L'ÉTUDE DE L'IMPORTANCE DES ACIDES AMINÉS DANS LA NUTRITION DES LARVES DE *Tribolium confusum*

| Principaux ingrédients | % | Vitamines | μgm. par gm. de régime |
|---|---|---|---|
| Mélange d'acides aminés | 20.7 | Chlorhydrate de thiamine | 1 |
| Sels* | 2.0 | Riboflavine | 2 |
| Huile de germe de blé | 1.5 | Chlorhydrate de pyridoxine | 1 |
| Cholestérol | 1.0 | Acide nicotinique | 8 |
| Levure | 0.5 | Pantothénate de calcium | 4 |
| Amidon | 74.3 | Choline | 1500 |
| | | Biotine | 0.05 |
| | | Acide ptéroylglutamique | 0.2 |

* *Mélange salin no. 2 U.S.P. XII.*

Dans le Tableau II, nous détaillons le mélange d'acides aminés employé dans le régime de base (Tableau I). Il est semblable à celui que Rose (8) a

TABLEAU II

COMPOSITION DU MÉLANGE D'ACIDES AMINÉS UTILISÉ

| Acides aminés | Gm. par 100 gm. de régime | Gm. d'azote par 100 gm. de régime |
|---|---|---|
| DL-alpha-alanine | 0.49 | 0.007 |
| L-arginine HCl | 0.59 | 0.158 |
| DL-acide aspartique | 0.49 | 0.052 |
| L-cystine | 0.24 | 0.028 |
| L-acide glutamique | 2.44 | 0.232 |
| glycine | 0.12 | 0.022 |
| L-histidine HCl | 1.05 | 0.230 |
| L-hydroxyproline | 0.12 | 0.013 |
| DL-isoleucine | 1.95 | 0.208 |
| L-leucine | 1.47 | 0.157 |
| L-lysine HCl | 1.83 | 0.282 |
| DL-méthionine | 0.98 | 0.092 |
| DL-phénylalanine | 1.47 | 0.125 |
| L-proline | 0.24 | 0.029 |
| DL-sérine | 0.24 | 0.032 |
| DL-thréonine | 1.71 | 0.201 |
| L-tryptophane | 0.49 | 0.067 |
| L-tyrosine | 0.73 | 0.056 |
| DL-valine | 2.44 | 0.292 |
| Bicarbonate de sodium | 1.59 | |
| Total | 20.68 | 2.353 |

composé pour déterminer les acides aminés essentiels au rat. Nous avons retranché tour à tour, de la diète de notre insecte, chacun de ces aminoacides et, dans chaque cas, nous avons remplacé le constituant supprimé par un

pourcentage égal d'azote, sous forme d'acide glutamique. Lorsque ce dernier fut retranché, nous lui avons substitué l'acide aspartique. De cette façon, nous avons toujours conservé le même pourcentage azoté, soit 2.353%.

Tous les régimes et mélanges ont été fabriqués et distribués selon les méthodes expérimentales exposées dans une autre publication (7).

## Résultats et Discussion

Tous les résultats que nous avons observés au cours de cet essai sont exposés dans le Tableau III.

TABLEAU III

IMPORTANCE DES ACIDES AMINÉS DANS LA NUTRITION DES LARVES DE *T. confusum*

| Acide aminé retranché | Larves vivantes le centième jour | Nombre de pupes sur 30 larves | Période moyenne de pupaison en jours ± $\sigma_m$ | Temps limites de pupaison en jours |
|---|---|---|---|---|
| Aucun (témoin) | — | 25 | 28.2 ± 0.48 | 24 – 34 |
| DL-alpha-alanine | — | 23 | 26.9 ± 0.43 | 24 – 33 |
| DL-acide aspartique | — | 24 | 29.2 ± 0.35 | 24 – 33 |
| L-acide glutamique | — | 20 | 30.1 ± 0.63 | 28 – 37 |
| L-cystine | — | 20 | 30.4 ± 0.55 | 27 – 35 |
| L-tyrosine | — | 24 | 30.6 ± 0.36 | 29 – 35 |
| glycine | — | 20 | 31.3 ± 0.57 | 28 – 36 |
| L-hydroxyproline | — | 22 | 32.3 ± 0.65 | 27 – 37 |
| L-proline | — | 26 | 32.7 ± 0.46 | 28 – 39 |
| DL-sérine | — | 19 | 32.7 ± 0.68 | 28 – 40 |
| L-lysine | 13 | 7 | 61.7 ± 3.87 | 52 – 78 |
| DL-thréonine | 15 | 3 | 66.3 ± 8.83 | 57 – 84 |
| DL-phénylalanine | 4 | 10 | 66.5 ± 3.83 | 47 – 78 |
| DL-méthionine | 11 | 4 | 68.5 ± 7.36 | 47 – 78 |
| DL-isoleucine | 16 | 5 | 69.8 ± 6.39 | 52 – 84 |
| L-arginine HCl | 12 | 4 | 70.5 ± 4.34 | 63 – 78 |
| L-leucine | 17 | 1 | — — | 66ème |
| L-tryptophane | 20 | 1 | — — | 84ème |
| L-histidine HCl | 20 | — | — — | — — |
| DL-valine | 24 | — | — — | — — |
| Farine de blé entier (régime naturel) | — | 22 | 18.3 ± 0.20 | 18 – 21 |

L'analyse de ces données indique clairement l'importance de certains acides aminés pour les larves de *T. confusum*. Dix d'entre eux se sont avérés essentiels. Ce sont: l'arginine, l'histidine, l'isoleucine, la leucine, la lysine, la méthionine, la phénylalanine, la thréonine, le tryptophane et la valine. L'omission de l'un ou l'autre de ces acides aminés n'empêche pas cependant les larves de vivre. Dans presque tous les cas, plus de la moitié des larves ont survécu et même quelques-unes ont réussi à puper. La croissance a toutefois été excessivement lente et un grand nombre de larves ont présenté une tache sombre médiodorsale que nous ne pouvons encore expliquer.

Si nous envisageons la nécessité des acides aminés par rapport à la pupaison, l'importance de la valine et de l'histidine ressort davantage. En effet, avec un régime privé de l'un ou l'autre de ces constituants, aucune larve n'a pu atteindre le stade pupal. Il semble bien aussi que le tryptophane et la leucine

aient la même importance puisque, en l'absence de chacun de ces acides aminés, une seule larve a réussi à puper. Au contraire, la phénylalanine semble moins nécessaire à la pupaison, car la privation de cette substance a tout de même permis la formation de dix pupes. Peut-être aussi existe-t-il une relation entre la phénylalanine et la tyrosine.

Il est intéressant de noter que les 10 acides aminés essentiels aux larves de *T. confusum* sont les mêmes que pour plusieurs mammifères, entre autres: le rat (8), le chien (9), la souris (1). Golberg et DeMeillon (3) ont obtenu des résultats presque semblables chez *Aedes aegypti*, qui exige seulement la glycine de plus que *T. confusum*. Malheureusement, ces auteurs n'ont pu définir le rôle de la valine. Les exigences en acides aminés de *Drosophila melanogaster* et de *Blattella germanica* sont moindres que celles de *Tribolium confusum* et d'*Aedes aegypti*. En effet la drosophile (5, 11, 12) requiert seulement le tryptophane, l'histidine, l'arginine, la lysine, la cystine et la proline. La blatte (4), cultivée aseptiquement, satisfait ses besoins azotés avec la valine, le tryptophane, l'histidine, la cystine et probablement aussi l'arginine. Elle se passe très bien de la glycine et de la méthionine.

L'obtention de tels résultats ouvre un vaste champ d'expériences, qui ont déjà été réalisées chez les mammifères et les oiseaux. Relation entre les acides aminés, utilisation de leurs différentes formes, valeur biologique des protéines, etc., voilà autant de problèmes qui peuvent être avantageusement étudiés avec les larves de *T. confusum* et dont la solution contribuera à accroître nos connaissances en nutrition comparée.

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# THE EFFECT OF COLD UPON THE CONCENTRATION OF VITAMIN C IN THE OOCYTES OF *ARION SUBFUSCUS* AND *DEROCERAS RETICULATUM*[1]

By Anne H. G. Watts[2]


## Abstract

Slugs of the species *Arion subfuscus* and *Deroceras reticulatum* were exposed to a temperature of 2° C. for periods ranging from 10 to 109 days. The vitamin C content of their primary oocytes as revealed by Bourne's two methods was found to be greater than that observed in controls kept at room temperature. The difference became apparent after 10 to 21 days of exposure and was maintained until the 45th to 50th day. After this time the level of vitamin C in the oocytes of the cold animals dropped again to normal, or even below, as the slugs aged and died.


## Introduction

Since its discovery by Szent-Györgyi in 1928, vitamin C has been studied extensively both chemically and cytologically, and many surveys of its distribution in vertebrate tissues have been carried out (Barnett and Bourne (1), etc.). Thérien and Dugal (6) have observed that at subnormal temperatures rats require a higher level of vitamin C in their tissues. The animals respond by synthesizing more of the vitamin, so that in successfully cold adapted animals the vitamin C content of the tissues shows an increase of up to 80% over the normal. Similarly, the guinea pig, which cannot synthesize the vitamin, requires an increased supply of ascorbic acid for successful adaptation to cold. The question arises as to whether the same phenomenon appears among the invertebrates, on which few studies of vitamin C and its distribution have been conducted.

## Material

A cytological study of the ovotestes of slugs belonging to the genera *Arion* and *Deroceras* has shown that vitamin C appears to be concentrated chiefly in the cytoplasm of the developing primary oocytes (Pelluet and Watts (5) ). It was decided to investigate the effect, if any, of cold upon the vitamin C content of these oocytes. The species *Arion subfuscus* (Draparnaud), and *Deroceras reticulatum* (Müller), were chosen for study, as being typical representatives of their respective genera. In all cases the ovotestes used were those of adult animals.

Preliminary experiments were conducted to determine whether or not the animals were capable of synthesizing vitamin C. Young slugs kept at room temperature were given a diet of oatmeal for periods ranging from one to four and one-half months. No decrease was observed in the vitamin C content of the ovotestes, so it was concluded that the animals could synthesize the vitamin.

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*Contribution from the Zoological Laboratory, Dalhousie University, Halifax, N.S.*
[2] *Aided by scholarships from the National Research Council of Canada.*

## Methods

Groups of 15 to 30 slugs were placed in the cold room at a temperature of 2° C. This is below the normal average temperature for these animals, which are generally found under boards where the temperature is above 5°C. The usual range in early spring and late autumn is 8° to 11° C. with slightly higher values during the summer. Control groups of the same size were kept at room temperature. During the early experiments the animals were fed on oatmeal, in order to avoid complications which might be caused by a diet containing vitamin C. Later this was replaced by a diet of lettuce, since experiments showed that this did not seem to alter the results, and the animals throve better upon it. Care was taken to supply equal portions of food to experimental and control groups.

The animals were kept in the cold for periods varying from 10 to 109 days, after which they were killed and the ovotestes treated according to Bourne's acetic – silver nitrate methods for the cytological demonstration of both reduced and total vitamin C. Material treated to demonstrate total vitamin C showed no increase in the vitamin over that treated to show the reduced form only. The only deviations from the methods as described in Lee's book (4) were variations in the time of fixation, according to the size of the material used. The first steps in the procedure were carried out in the dark at 2° C.

These methods have been shown to be reliable (Bourne (2) ), and have been widely used to demonstrate vitamin C in vertebrate tissues. Though little work has been done on invertebrate material, the methods have been found satisfactory where used, as for example on insect tissues, as described by Day (3).

Sections were cut at 6 to 10 $\mu$, and the size and number of the black granules indicating sites of vitamin C were compared for experimental and control animals. A grid micrometer inserted in the ocular of the microscope proved useful for final comparisons, and the assistance of several people who acted as "blind counters" was most helpful. Results observed with the ordinary light microscope were checked under the phase microscope.

## Observations

Forty-four experiments involving about 600 animals were carried out.

Upon first being placed in the cold, the slugs underwent a brief shock period of inactivity, lasting for one to two days, after which they regained their normal activity and appetite. On the whole, *Deroceras reticulatum* became adapted more readily than did *Arion subfuscus*, which is in keeping with the observation that very few adults of the latter species are found during winter collecting trips. Since the two species gave slightly different results in the experiments, it will be more convenient to consider them separately.

*Deroceras reticulatum*

After 10 days' exposure to cold, animals of this species showed a higher vitamin C content in the cytoplasm of their oocytes than did the controls

(Table I and Figs. 1 and 2). This difference remained apparent in animals killed up to the 50th day of exposure, after which it showed to a lesser degree. In the oocytes of animals killed on the 60th day, the vitamin C content was

TABLE I

MEAN NUMBER OF GRANULES OF VITAMIN C PER GRID SQUARE IN COLD AND CONTROL SLUGS. EACH VALUE IS THE MEAN OF THE GRANULE COUNT FOR AT LEAST 70 GRIDS AS SHOWN IN FIGS. 2 AND 4

| Days | *D. reticulatum* | | *A. subfuscus* | |
|---|---|---|---|---|
| | Cold | Control | Cold | Control |
| 10 – 20 | 15.83 ± 1.23* | 5.44 ± 0.69 | 12.2 ± 1.2 | 12.2 ± 1.6 |
| 21 – 30 | 13.91 ± 1.46 | 4.79 ± 1.01 | 21.8 ± 3.1 | 5.7 ± 0.9 |
| 31 – 40 | 15.73 ± 1.60 | 8.30 ± 1.09 | 22.9 ± 2.7 | 9.9 ± 1.6 |
| 41 – 50 | 22.33 ± 1.71 | 10.03 ± 1.10 | 27.3 ± 2.6 | 8.1 ± 0.7 |
| 61 – 70 | 9.2 ± 0.81 | 8.0 ± 0.94 | 16.0 ± 1.8 | 11.4 ± 0.8 |
| 100 – 109 | — | — | 4.5 ± 0.5 | 9.5 ± 0.6 |

* $\sigma M$, *standard error of the mean* $= \frac{\text{standard deviation}}{\sqrt{n}}$.

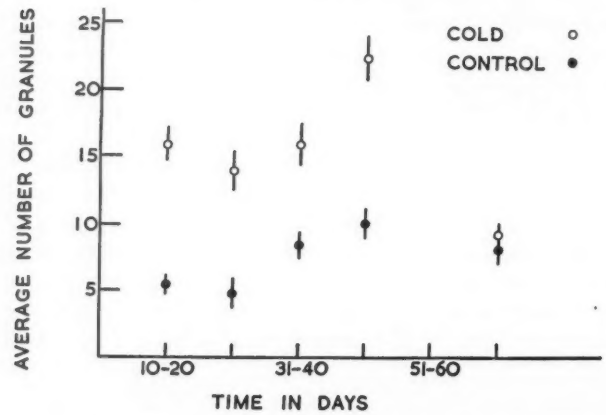



FIG. 1. Vitamin C in the oocytes of *D. reticulatum*. Average number of granules of vitamin C per square of grid micrometer plotted against time in days. The standard errors of the means are indicated by the vertical lines on either side of the points.

about the same as that in the oocytes of the controls and did not again rise significantly above the latter. From this time up to the 105th day, the amount of vitamin C in the oocytes of the experimental animals wavered up and down, now slightly more, now less, than that seen in the controls. Few of the animals remained alive after this time. (See Figs. 5 and 6.)

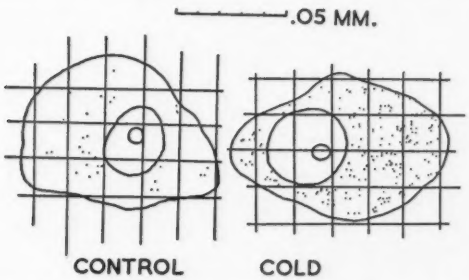



FIG. 2. Camera lucida drawing of vitamin C granules as seen in oocytes of *D. reticulatum*. The squares of the grid micrometer are superimposed upon the oocytes. The oocyte on the right is from an animal kept at 2° C. for 15 days.

*Arion subfuscus*

From the 10th to the 21st day of exposure to cold, little difference in amount of vitamin C could be distinguished between the oocytes of control and experimental animals (See Table I, and Fig. 3). Where a difference could

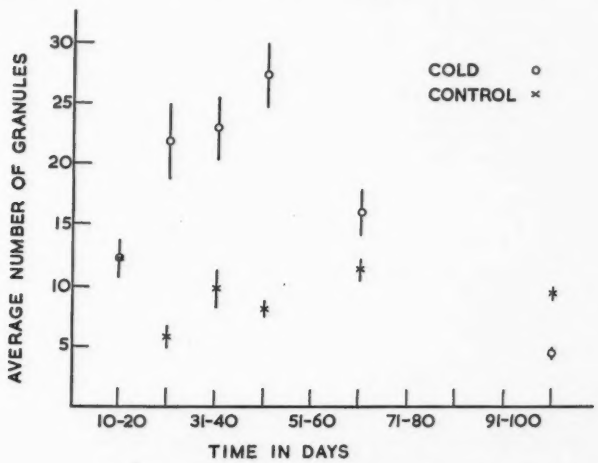



FIG. 3. Vitamin C in oocytes of *A. subfuscus*.

be said to occur at all, it was caused by a small decrease in the vitamin in the cold animals. After this time, in the cold animals there was an increase in the vitamin above the normal, which was maintained up to about the 44th day (See Fig. 4, and Figs. 7 and 8). From this period through to the 109th day, little difference could be detected between oocytes of experimental animals and controls.

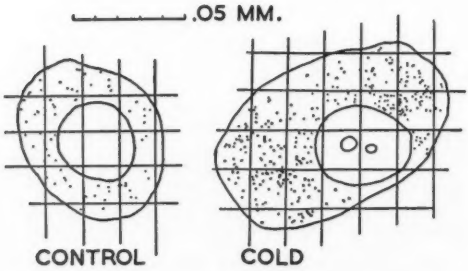



FIG. 4. Camera lucida drawing of oocytes of *A. subfuscus* showing vitamin C granules. The oocyte on the right is from an animal kept at 2° C. for 31 days.

## Discussion and Conclusion

It appears from these experiments that a decrease in temperature results in an increased concentration of vitamin C in the cytoplasm of the oocytes of *Arion subfuscus* and *Deroceras reticulatum*. This higher concentration is reached within 10 to 21 days of exposure to cold and is maintained up to about the 50th day of exposure, after which the level falls once more until it is the same as, or even less than, that seen in the controls. It should be noted here that the life of a slug is short, usually less than a year, and since the animals were already adult when the experiments were begun, 50 days later they might be considered to be ageing rapidly and losing their ability to adapt themselves to environmental changes. This could account for the failure to maintain the higher level of vitamin C in the oocytes towards the end of the experiments.

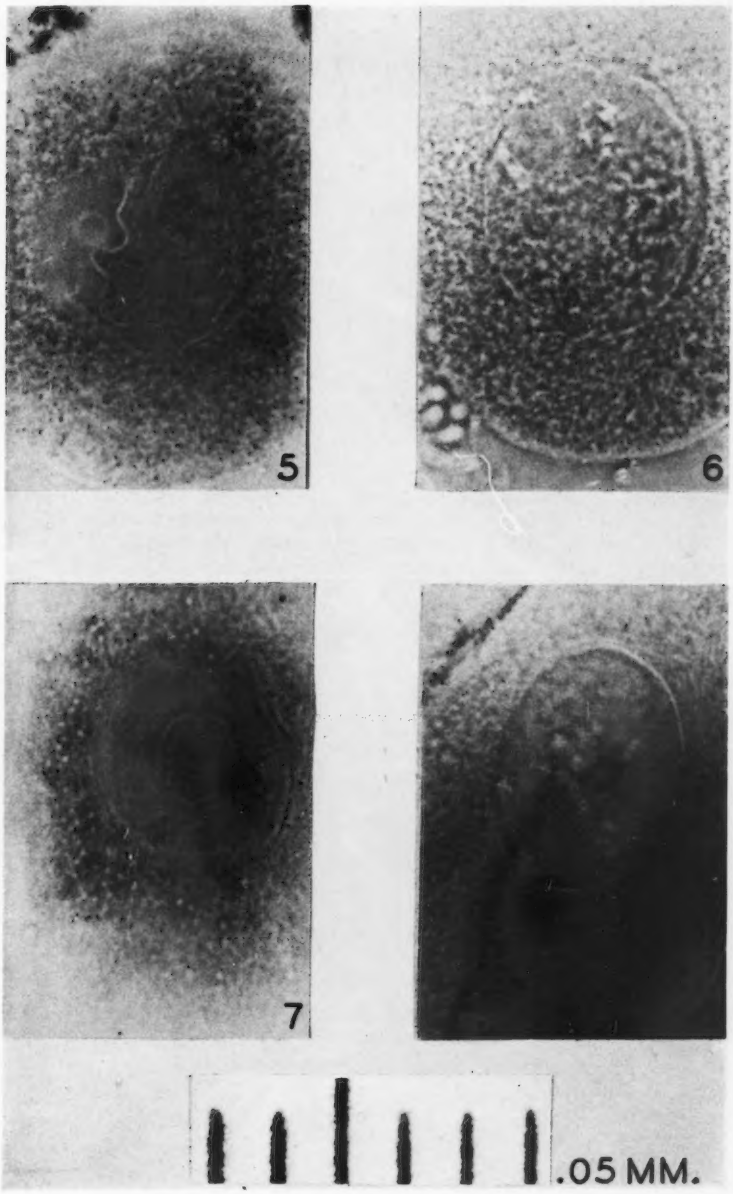
It cannot be concluded from these experiments that an increased vitamin C concentration in the oocytes of animals exposed to cold aids the animals in adapting themselves to the lower temperature. In that connection the vitamin C concentration in other organs would have to be studied, for the oocyte is influenced by the condition of the animal rather than the animal by the oocyte. It can, however, be stated that in slugs successfully adapted to cold, the concentration of vitamin C in the cytoplasm of the oocytes is greater than that in the oocytes of the controls.

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FIGS. 5-8. Phase microscope photographs. FIG. 5. Oocyte of *Deroceras reticulatum* kept at 2° C. for 45 days. Black granules show sites of vitamin C activity. FIG. 6. Oocyte of control *Deroceras reticulatum*, 40 days after the beginning of the experiment. FIG. 7. Oocyte of *Arion subfuscus* kept at 2° C. for 38 days. The light spots are granules just out of focus. FIG. 8. Oocyte of control *Arion subfuscus* 38 days after the beginning of the experiment.

*Note:* The scale is part of a stage micrometer photographed with the same lens combination as the oocytes and projected to the same size. Each division = 0.01 mm.

PLATE I



## Summary

The concentration of vitamin C as revealed by Bourne's methods was studied in the oocytes of *Arion subfuscus* and *Deroceras reticulatum* exposed and adapted to a temperature of 2° C. This was compared with the concentration found in the oocytes of control animals kept at room temperature and was observed to be greater than the latter. The difference became apparent in *D. reticulatum* after the 10th day of exposure, and after the 21st day in *A. subfuscus*. This higher concentration was maintained in healthy animals up to about the 50th day, after which it dropped again to normal, or even below, as the animals aged and died.

## Acknowledgments

I wish to take this opportunity to express my thanks to Dr. D. Pelluet, for her advice and assistance; to Miss H. B. Bridgeford, Miss M. S. McCoy, and Mr. J. S. Tait, who acted as "blind counters"; and to Mr. M. L. Cameron, who read the manuscript, and worked jointly with me on the photography.

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# SELECTION FOR DDT TOLERANCE IN A BENEFICIAL PARASITE, *MACROCENTRUS ANCYLIVORUS* ROH.

## I. SOME SURVIVAL CHARACTERISTICS AND THE DDT RESISTANCE OF THE ORIGINAL LABORATORY STOCK[1]

By D. P. Pielou[2] and R. F. Glasser[2]


## Abstract

*Macrocentrus ancylivorus* Roh. is a short-lived insect, a fact which must be taken into account in any experimental work on this species. Well fed females have a mean life of about five days. In the absence of food, but in the presence of water, this period is reduced to one and one-half days. In the absence of water and in dry air it is not much further decreased; adequate nutrition seems to be the main survival factor. Exposure of young adults to films of crystalline DDT in celloidin, for a few minutes, results in a heavy initial mortality with the toxic action completed within 40 hr., subsequent deaths being due to natural mortality. In all experiments males were more susceptible than females. In view of the short life of the insect, the results can be conveniently expressed in survival, or longevity, curves; these show the quantitative effects of the DDT in destroying part of, and in affecting the natural decline of, the experimental populations. Examination of the death rate among the tail of survivors of such DDT treatments shows that destruction has been selective, and that these insects die more slowly than those in the controls.


## Introduction

The destruction of beneficial insect parasites by insecticidal treatments directed against pests which are their hosts has caused concern among those who appreciate the importance of parasites in the control of insect populations. This concern is heightened by the increasingly frequent appearance of newer and more powerful poisons, and with the greatly enlarged scale of insecticide operations in the past few years. At the same time it has become clear that various species of insects can develop tolerance to insecticides (Babers, 1949 (1) ). It is therefore a fairly obvious procedure to attempt to produce, by selective breeding, parasites that are resistant to insecticides. The release, successful establishment, and colonization of such parasites would do much to solve problems in instances where chemical control is at variance with biological control. At the Belleville laboratory efforts are being made to produce a DDT-resistant strain of *Macrocentrus ancylivorus* Roh., a very effective parasite of the oriental fruit moth. In the Niagara Peninsula of southern Ontario this parasite is the most effective single control agency of the moth, itself the most important pest of peaches in the area. The appearance of this moth about 1925 threatened to ruin the peach growing industry until its parasite enemy was introduced in 1929; the effective establishment of the latter was followed by a speedy decline of the moth (van Steenburgh, 1930 (13), van Steenburgh and Boyce, 1938 (14)). To-day, however, extensive

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DDT spraying, used to supplement the control effected by *M. ancylivorus*, threatens the existence of the parasite as much as it does that of the host moth. In any one season the elimination of the parasite, without extinction of the host, may have disastrous consequences. The production and establishment of a DDT-resistant strain of *M. ancylivorus* would provide some practical safeguard against this possibility.

## Some Natural Factors Affecting Survival

Previous investigators have noted that *M. ancylivorus* has a short life. Fink (1926 (6) ) briefly notes an average life of eight days for females and five for males. As a basis for work on DDT tolerance, observations were made on natural mortality and factors affecting it. The insects were reared according to the method of Finney, Flanders, and Smith (1947 (9) ); the stock has been propagated in this way for some years in this laboratory. Each day, the young emerging adults were sorted into separate sexes and placed in half-pint bottles. Fifty adults were placed in each bottle. The bottles were closed with standard milk-bottle caps, but each cap was perforated with a hole in which was inserted a plug of dental cotton roll about 2 in. long (Fig. 12). This cotton roll had been previously soaked in a 10% solution of sucrose and so provided food and water for the adults. *M. ancylivorus* adults live satisfactorily on sugar solutions, as do many other adult insects once growth is completed, e.g., *Drosophila melanogaster* Meig. (Hasset, 1948 (10) ). Extra solution was pipetted onto the top of the plug each day; evaporation from the plug kept the air in the bottle saturated. A small, white filter paper was placed in the bottom of each bottle. The numbers of insects dying, and the surviving population, were recorded each day. The experiments were carried out, as were all described in this paper, in constant temperature rooms maintained at 26.5° C. In Fig. 1 the curve labelled "saturated air + sugar solution" shows the decline of the population of females up to the 11th day of life; in Fig. 2 the corresponding curve is shown for males. Each of these curves is based on an initial population of 3000 insects. It will be seen that half the population of females is dead in a little less than five days; that of males in a little less than four days. Further experiments showed that very few individuals of either sex lived as long as 15 days. (Survival was not as good when the same test was carried out in large airy cages; on the contrary the narrow confines of the test bottle and closer proximity of the feeding solution apparently provided better conditions for survival.) The experiments were then repeated in identical fashion, except that the sugar soluton in the dental rolls was replaced by water. The curves marked "saturated air + drinking water only" in Figs. 1 and 2 show the resulting population decline in the two sexes. Half the population of females is dead in 36 hr., and half that of the males in 22 hr. A further experiment was carried out in which no drinking water was provided but in which the insects were kept in desiccators under controlled conditions of humidity. Sulphuric acid solutions

were used to control humidity (Wilson, 1921 (15) ). Tests were conducted at 5% relative humidity and at 90% R.H. The results obtained are shown in further curves in Figs. 1 and 2. At the higher relative humidity a result is

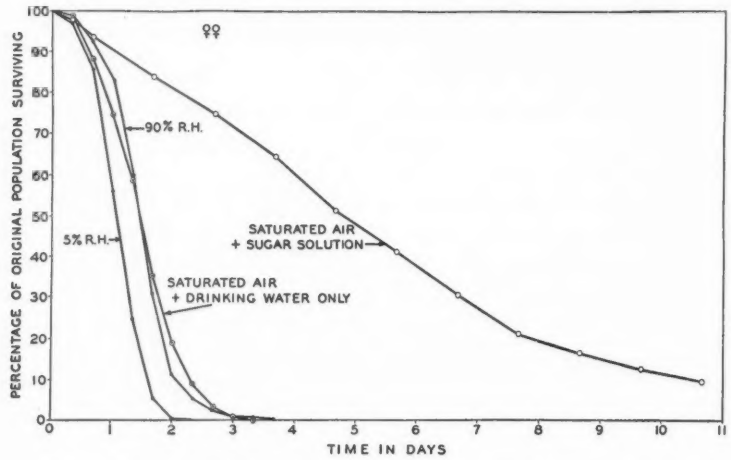



FIG. 1. Curves showing decline of populations of females: in air at 5% and 90% R.H. without food or water, in saturated air with drinking water, and in saturated air with food and water. Right-hand curve drawn from data on 3000 insects; remaining three from data on 1000 insects each.

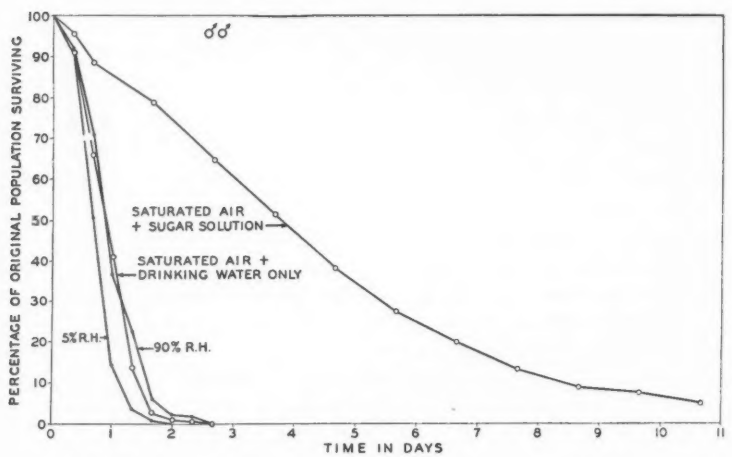



FIG. 2. Curves showing decline of populations of males. Conditions and numbers as in Fig. 1.

obtained scarcely different from that recorded when drinking water is provided; and even in very dry air, at 5% R.H., the mortality is but slightly increased. The entire set of results recorded in Figs. 1 and 2 indicate that adequate food

is the main factor in the survival of these experimental populations and that in the absence of such food other factors do not much affect the rapid decline of the populations.

## Method of Testing for DDT Toxicity

The method of exposure was to confine insects on films of the insecticide for a few minutes. It was desired to use test chambers of constant size, on the inner surfaces of which had been deposited uniform films of DDT. Each of these films had to contain a prescribed quantity of DDT deposited entirely in the crystalline state over a prescribed area. The importance of using a crystalline deposit of insecticide in contact tests is now generally appreciated; for instance if a solution of DDT dissolved in acetone is allowed to evaporate, some of the DDT crystallizes but some is left in an unstable state and this crystallizes subsequently over an extended period, or as a test insect walks across it (Cvetanovic, 1949 (3) ). This is obviously undesirable in critical quantitative work and for this reason we ruled out, for instance, the method described by Browning *et al.* (1948 (2) ), although their technique is a convenient one for the rapid assessment of insecticidal chemicals. Patton and Sarkaria (1948 (11) ) describe a method of depositing crystalline DDT by mixing dry DDT crystals with starch as a carrier, dispersing the mixture from a dust tower, and washing the starch away from the plates upon which the mixture has fallen. The method was considered too awkward for regular daily use; moreover, it would be difficult to deposit repeatedly specified amounts in a circumscribed area. Extensive tests on various possible methods, by the senior author, showed that the most satisfactory films could be obtained by depositing the DDT from a solution of celloidin in a mixture of ether and alcohol. This new method has been briefly described by Pielou (1950 (12) ). The celloidin ('Parlodion', mixture of the lower nitrates of cellulose) is of the usual histological grade. A 0.2% solution is made up in its usual solvent, a mixture of equal parts by volume of absolute ethyl alcohol and anhydrous ethyl ether. Pure para para DDT (m.p. > 108° C.) is dissolved in this to make up concentrations of 0.3%, 0.6%, and 0.9% of the insecticide. A lantern slide cover glass, $3\frac{1}{4}$ in. × 4 in., is very thoroughly cleaned with a solvent and lens paper. In the center of this glass, a circle is then drawn, 2 in. in diameter, with a grease china-marking pencil. A guide, cut from masonite, allows this to be done easily and cleanly. From a microburette or Mohr pipette 0.15 ml. of celloidin–insecticide solution is run onto the middle of the cover glass (Fig. 3). If the cover glass is perfectly clean the solution spreads out rapidly as a very thin film with a circular outline until it is stopped by the grease-pencilled circle. Evaporation of the solvents proceeds rapidly and after approximately 30 sec. the film is touched lightly with a needle that has previously been in contact with the insecticide. This "seeding" induces centers from which crystallization proceeds rapidly and completely through

the film as it dries. If it dries too rapidly the celloidin hardens before crystallization is complete. To retard evaporation the deposit circle can be surrounded by a brass ring, flat on both faces, and then covered with a second cover glass. The operation is shown in progress in Fig. 4. The stages in the race between evaporation and crystallization can be observed most easily if the operation is performed on a glass-topped box illuminated from below as shown in Fig. 4. At the critical point the second cover glass is put on. The lower cover glass with its drying film, the ring, and the upper cover glass lid are then removed bodily, as one unit, from the illuminated box and put on one side. Crystallization is completed after some hours. An alternative method of ensuring complete crystallization is to place the cover glass, with the drying deposit face downwards, on a vessel containing some of the alcohol–ether solvent. This vessel must have flat-ground edges so that close contact is made with the cover glass (Fig. 5). Under these circumstances evaporation from the celloidin is very slow indeed because it takes place in an atmosphere of ether and alcohol vapor. By next day crystallization is complete. Both methods produce beautiful crystals branching regularly, like some vegetative growth, from the centers of crystallization (Figs. 6, 7, 8). A few films have to be discarded because of irregular branching of the crystals or lack of uniformity. There is, however, no difficulty in making 70-100 suitable films in half a day. When crystallization is complete and the films are dry, the celloidin base is estimated to be 0.15 $\mu$ thick. The cover glasses may be stacked up for a time until needed; a standard 5 × 3 in. card index drawer fitted with slotted racks is very convenient for storage. The DDT films retain their insecticidal power for months. For experimental use the test chamber (Fig. 9) is made by placing two cover glass films face to face but separated by a flat brass ring 3/16 in. thick and of internal diameter equal to the deposit circle. (Such rings can be made by parting off, on the lathe, lengths of standard heavy-gauge brass pipe of suitable diameter.)

Originally ether (12) was suggested as an anesthetic for handling insects in the chamber. This is satisfactory for some insects but is not suitable for *M. ancylivorus* which is easily killed by it. Carbon dioxide was found to be a suitable alternative. Insects, 50 at a time, are stupefied with the gas and put in the chamber; they recover in a matter of seconds. This rapid recovery overcomes a difficulty encountered if ether is used, for in this case insects

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FIG. 3. Pipetting celloidin – DDT solution onto slide; showing grease-pencilled circle.

FIG. 4. "Needling" the drying film to induce centers of crystallization; a second cover glass is ready to be placed in position at the critical stage; illumination from below permits easy estimation of this stage.

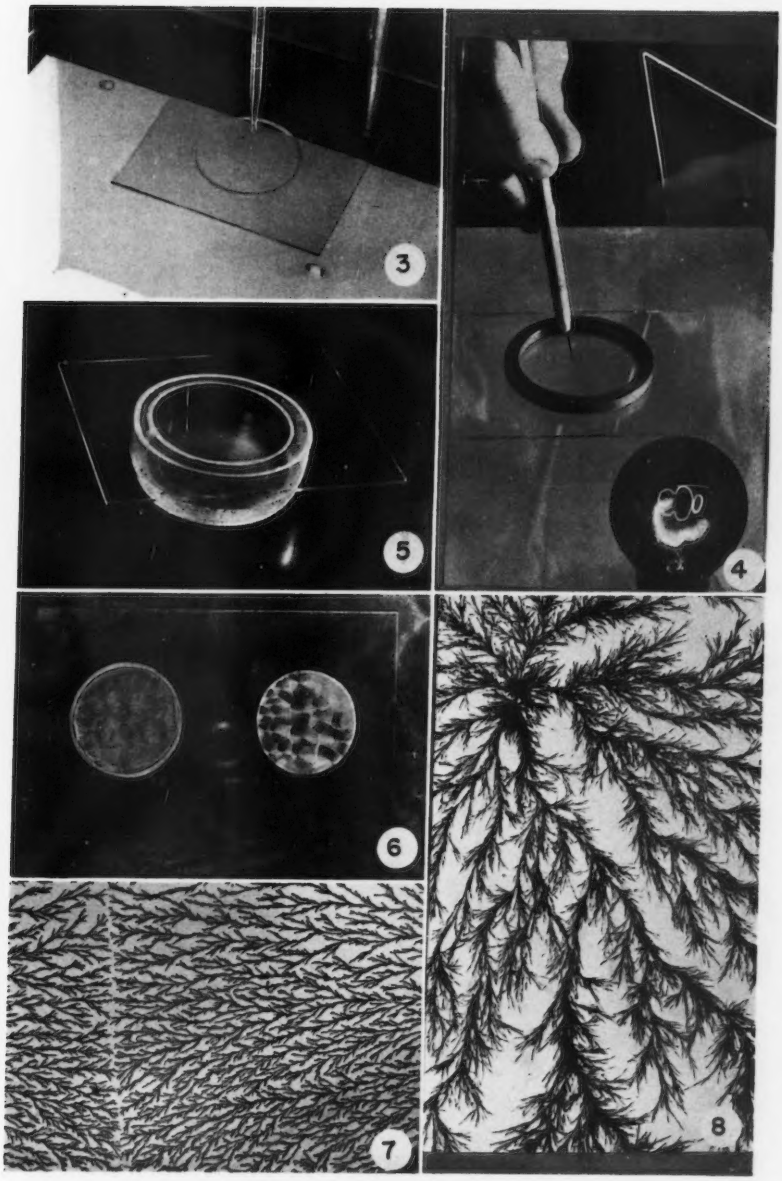
FIG. 5. An alternative method of inducing crystallization; slow evaporation of solvents in an atmosphere of ether and alcohol; the grease-pencilled circle delimiting the film area is visible.

FIG. 6. Two completed films. Left, DDT density of 23 $\mu$gm. per sq. cm.; right, 69 $\mu$gm. per sq. cm.

FIG. 7. General crystal structure. ×60.

FIG. 8. A center of crystallization. ×200.

PLATE I



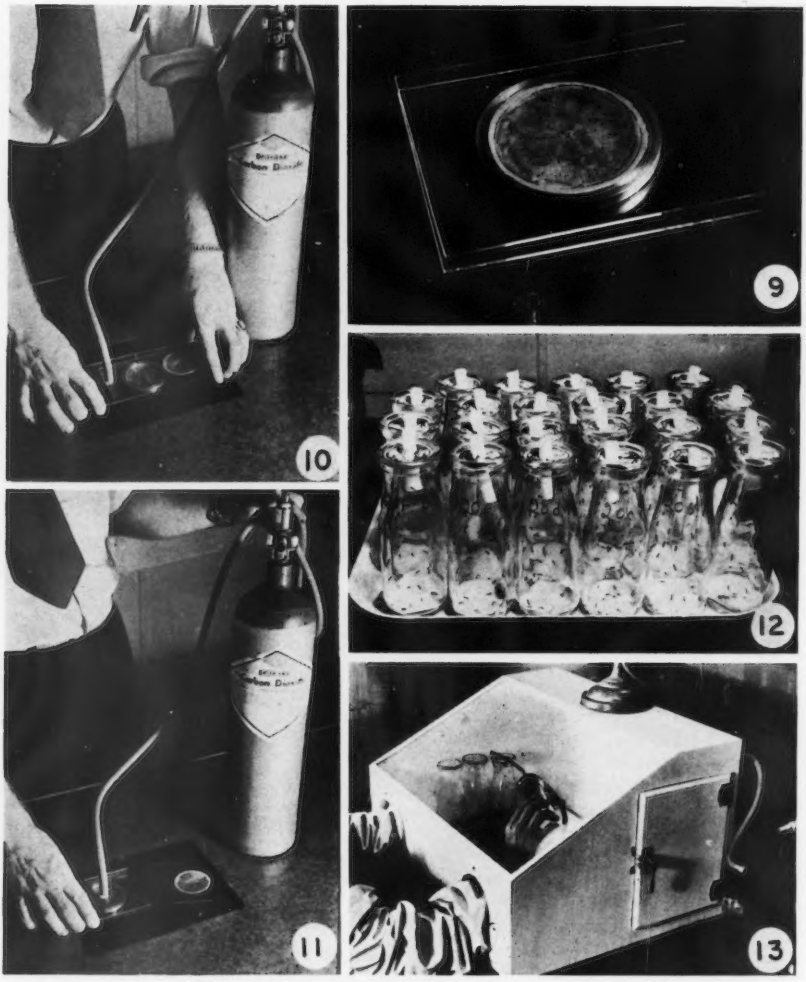



FIG. 9. Test chamber; two films face to face and separated by a brass spacer ring.

FIG. 10. Completion of test: replacement of upper slide by a baffle preparatory to stupefaction with carbon dioxide.

FIG. 11. Stupefaction of test insects.

FIG. 12. Exposed insects in survival bottles; the dental cotton plugs are soaked in sugar solution.

FIG. 13. Separating living from dead insects with a suction collector inside a closed handling box.

remain anesthetized and inactive for a considerable period of the total exposure time and an awkward allowance must be made for this in assessing dosage. In order to remove the insects from the chamber, when the test is completed, the upper cover glass is lifted a little (to avoid scratching the film) and moved across, being replaced at the same time by a lucite baffle (Fig. 10). This baffle has a hole in the center through which carbon dioxide can be supplied from a tube connected to the gas cylinder (Fig. 11). The insects are stupefied again and removed rapidly from the test film. They are placed in survival bottles, of the type already described, and provided with sugar solution (Fig. 12). Subsequent deaths in these bottles are noted at intervals. The dead insects can easily be counted as they fall upon the white paper at the bottom of the bottles. In some experiments on selective breeding it is necessary to separate the living from the dead after a given time. This is conveniently done by opening the bottles in a closed, illuminated handling cabinet (Fig. 13) and removing the survivors, who fly to the observation window, with a power suction collector. Trial tests have shown that at least 20 tests can be run in succession with the same pair of films without decreasing their toxicity; in practice we restrict each pair of films to use in not more than 10 tests.

## Quantitative Results of Exposure to DDT

Preliminary trials had shown that a film made from a 0.3% DDT solution and calculated as containing 23 μgm. of insecticide per sq. cm. was suitable for experiment. A series of definitive experiments was then carried out in which insects were exposed to films of this density for times of one, two, three, four, six, and eight minutes. Separate tests were performed on each sex. A total of 1000 insects, in lots of 50 as already described, were used for each exposure time and for each sex. Because of the numbers involved the exposures had to be spread over a number of days. The tests were arranged so as to be randomized in time, i.e., the same number of tests was carried out on any one day for each exposure time and for each sex. This is essential because there are certainly daily variations in the average "vigor" and in the insecticide responses of insects. This sort of day-to-day variation occurs in spite of every effort being made to keep to a precisely uniform procedure in the breeding practices. Variations of this type are common and various statistical techniques have, in fact, been devised to reduce error from this source. The survival of test insects in the feeding bottles was recorded 8, 16, and 40 hr. after the exposures and then at further 24 hr. intervals until the 11th day when survival in the controls was less than 10%. The general results are summarized, for females, in Fig. 14 and, for males, in Fig. 15.

Examination of the slopes of these curves shows that most of the lethal effect takes place in the first 16hr. and is completed within 40hr. The results summarized in these graphs are for "time–dosage" exposures at one specified density of DDT, i.e., 23 μgm. per sq. cm. A similar series of experiments

was carried out at a constant time of exposure (two minutes) but at varying concentrations of DDT, i.e., at 23, 46, and 69 μgm. per sq. cm. Otherwise, conditions of experiment were identical and similar numbers of insects were

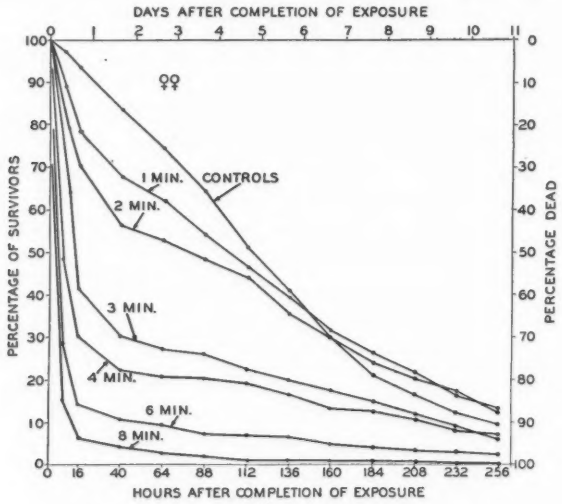



FIG. 14. Population decline of females in controls (natural mortality) and after varying time exposures to a DDT film of 23 μgm. per sq. cm. Control curve drawn from data on 3000 insects; others from data on 1000 insects each.

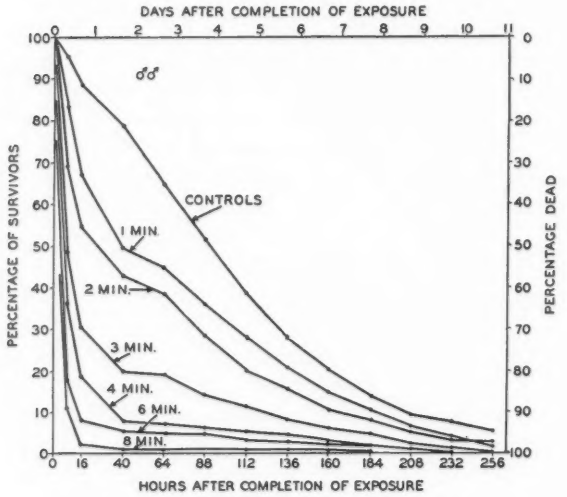



FIG. 15. Population decline of males; conditions and numbers same as in Fig. 14.

used. Fig. 16 summarizes the results for females. The data for males present a similar picture except that, as with females, population decline is somewhat greater in both controls and tests. The curves in these figures,

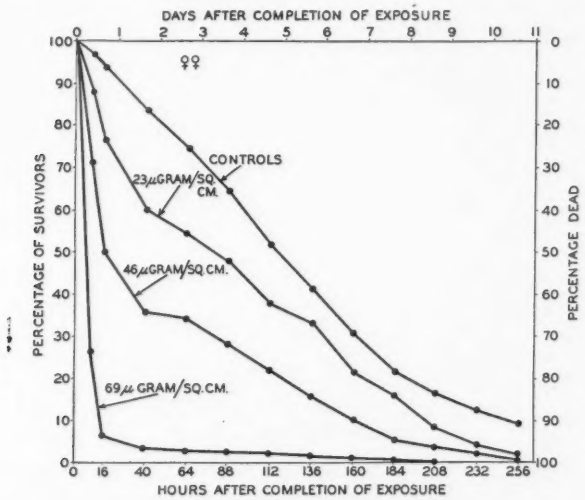



FIG. 16. Population decline of females exposed for two minutes to varying densities of DDT film; numbers of insects as in Fig. 14.

except that they are truncated at the 11th day, are similar to the "Survival curves" of demographers dealing with human populations (Dublin and Lotka, 1936 (5) ), the data upon which they are based being similar to the $l_x$ data of actuarial life tables. Our results are, however, presented in percentages instead of in numbers per 100,000. A few minutes' exposure to DDT represents, in our tests on *M. ancylivorus*, a catastrophe of short duration to which one age group only (young, newly emerged insects in their first day of adult life) is exposed once in a lifetime. The curves in Figs. 14, 15, and 16 show the effect of this event on the subsequent population structure. These catastrophic events produce a strongly concave survival curve of the type characteristic of certain animals, e.g., the oyster, of which a great majority are short-lived but of which a minority survive to enjoy a life span many times greater than the mean (Deevey, 1947 (4) ).

Further information is provided by plotting some of the data in different ways. For instance, Fig. 17 shows the percentage of the original population that die on each day.

To avoid confusion on the graphs, curves are shown only for controls and for the four-minute exposure to the 23 μgm. film. The data are compiled in a form similar to that of the $d_x$ column in life tables except that once again

percentages are used. These curves clearly emphasize that the action of the DDT is over within two days and that the subsequent deaths in the reduced population are a reflection of the natural mortality in the controls. The

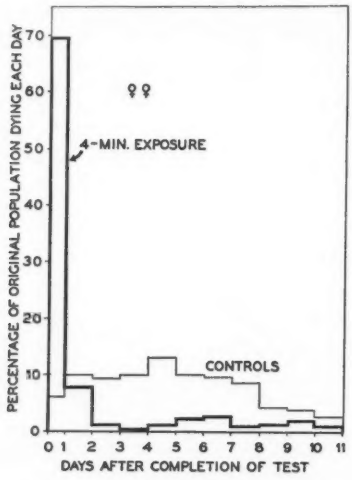



FIG. 17. Percentage of the original population dying each day in controls and in those subjected to a four-minute exposure; curves truncated on 11th day, when over 90% were dead in both cases. The first "day" is, for technical reasons, a 16 hr. period.

same cases are presented in another, and more informative, form in Fig. 18. Here the daily mortality or death rate has been calculated and expressed as a daily probability of death, that is, as a ratio of the number dying in a given day to those alive at the beginning of the day. The data used are similar to those in the $q_x$ column of life tables except that the latter are usually expressed as deaths per 1000. It will be seen that after the high death rate of the first two days of adult life, the death rate among survivors is decidedly lower than in the controls. The same general relation is apparent if curves for other exposure times are plotted. This demonstration is of some importance, because it shows that the catastrophic destruction by DDT of the major part of the population has been selective rather than random: the survivors (who are presumably more tolerant of DDT) are also those with a relatively long life span. Though there is nothing in the evidence at present to suggest that variation in the populations from which we have selected individuals in this way contains a genetic element, it is from the tail of survivors that we intend to breed for possible inheritance of DDT tolerance.

From the general data we can also plot conventional probit regression lines for toxic effect of DDT, after due allowance has been made for heavy natural mortality (Finney, 1947 (7), 1949 (8) ). For completeness a whole set of

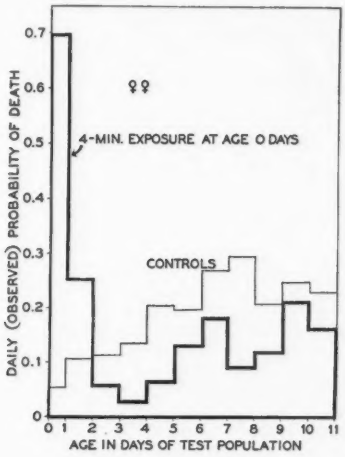



FIG. 18. Daily death rate, or probability that insects alive at beginning of $n^{th}$ day will die before the end of it; experimental conditions as in Fig. 17.

probit lines should be drawn covering evaluation times from the first eight hour record of survival and subsequently until cessation of the experiments on the 11th day. The labor of computation is too great to make the results worthwhile since increasing natural mortality decreases the weight to be attached to the figures for experimental mortality; and the low percentages of survival, in all cases after the first few days, provide an unsatisfactory spread of points for plotting probit lines. The lines computed have therefore been confined to the 8-, 16-, and 40-hr. evaluation periods: these are the most logical values because they cover the time when the DDT is acting on the population (Fig. 19). The 40-hr. line would appear to give the best 'probit' picture since this time is the earliest at which the action of the DDT can reasonably be said to be complete and the range of percentage survival values still makes a fairly good spread across the probit scale.

Probit lines provide a very exact means of statistical comparison; but, although corrections can be made for control mortality, they are not really designed for cases in which the duration of an experiment covers a large portion of the life history of a test insect. In spite of the statistical advantages of the probit method it is felt that the various life curves are more illuminating for a short-lived insect like *M. ancylivorus*.

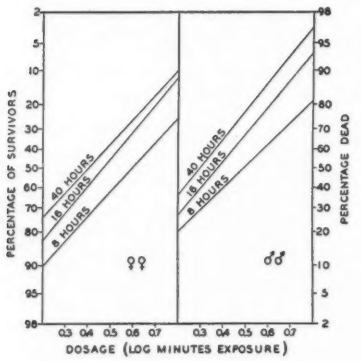



FIG. 19. Probit lines showing regression of mortality on dosage at 8-, 16-, and 40-hr. evaluation times; adjusted for control mortality.

## Discussion

Experimental work on insects that are naturally very short-lived presents problems that do not arise with forms that live longer, e.g., cockroaches, flour beetles, and fruit flies. Insects of the latter type have been more frequently used in experimental studies for the very reason that they are hardy and have a slow natural mortality. Many insect parasites, which as a group play a most important part in the balance of insect populations, are fragile insects with a short adult life. This shortness of life must imply great efficiency in some of their ecological responses, e.g., in timing of emergence, behavior in searching and oviposition; otherwise they would not survive; it is itself worthy of further study. In describing this shortness of life, various curves, based on data presented as in the life tables of demographers (5) provide a vivid means of description. Deevey (1947 (4) ) has drawn attention to the value of life tables in making ecological comparisons between different species of animals. We feel that this is particularly so in the case of short-lived parasites; their very shortness of life is convenient in making the necessary experimental observations for compilation of the data. Besides allowing this comparison of species under optimum conditions of survival, the curves are perhaps more valuable in providing a ready means of illustrating the effect of sudden and catastrophic events (such as peaks of high temperature, cold spells, or of human interference as in insecticide application) on the subsequent population structure. From the initial descriptive phase one may then proceed to study the effect of these sudden, induced changes on population size and degree of parasitization of the host, on the relation between competitors, and on genetic selection. In this last connection work is continuing on the action of DDT destruction, as described in this report, in selecting both for DDT tolerance, and for concomitant changes.

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# DESCRIPTION OF *METABRONEMA PREVOSTI* SP. NOV. WITH A NOTE ON THE GENUS AND A LIST OF ITS SPECIES AND THEIR HOST AND GEOGRAPHICAL DISTRIBUTION[1]

By L. P. E. Choquette[2]

## Abstract

*Metabronema prevosti* sp. nov. is described from *Ameirus nebulosus nebulosus* (Le Sueur) and the systematic status of the genus *Metabronema* Yorke and Maplestone, 1926, in relation to other spirurid genera is reviewed briefly. A list of the species of the genus, their hosts, and geographical distribution is given.

While studying nematodes from the bullhead (*Ameiurus nebulosus nebulosus*) collected in 1939 from the Ottawa River, the writer has found a hitherto undescribed species of the genus *Metabronema* Yorke and Maplestone, 1926. The material consisted of two males in rather poor condition (one could not be examined satisfactorily) and 14 females, all of which had been preserved in 70% glycerine–alcohol. This species is described under the name of *Metabronema prevosti* in honor of Monsieur Gustave Prévost, Office of Biology, Department of Fish and Game, Province of Quebec, for his constant help in securing material of value in parasitological studies.

## *Metabronema prevosti* nov. sp.

These worms are slender and attenuated in shape with the greatest width at a short distance from the posterior extremity and gradually narrowing to the anterior end. The cuticle shows regular transverse striations. The females measure 9.4 to 13.2 mm. in length; the male: 7 mm. in one specimen and 10.0 mm. in the other. Measurements given here for the male are, unless otherwise indicated, those computed from the type specimen.

The oral opening (Fig. 1) is dorsoventrally elongated and surrounded by two slightly trilobed pseudolabiae. Only the cephalic papillae of the external circle were observed, and consist of four large papillae located at the base of the pseudolabiae. The mouth leads into a vestibule 0.10 to 0.16 mm. long in the female and 0.12 mm. in the male. The oesophagus is divided into an anterior portion and a posterior one which is much the longer. The anterior muscular portion varies from 0.22 to 0.39 mm. in length while the posterior glandular one is 1.67 to 2.35 mm. long in the female; in the male they are respectively 0.38 and 2.91 mm. long. In the female worm the total length of the oesophagus is about one-fifth of the total body length. The nerve ring placed on the anterior portion of the oesophagus is 0.14 to 0.20 mm. from the

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anterior extremity in the female and 0.19 mm. in the male, while the excretory pore is 0.22 to 0.25 mm. from this extremity in the female and 0.30 mm. in the male.

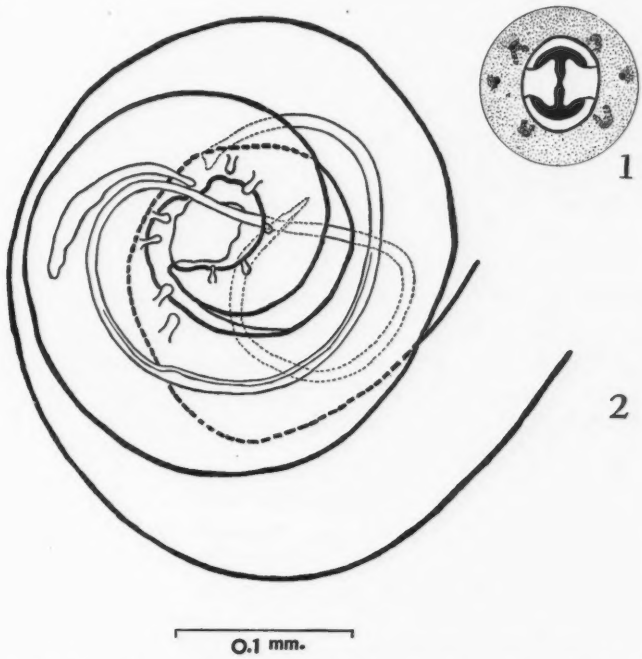



FIG. 1. *Metabronema prevosti.* *En face* view of anterior extremity.
FIG. 2. *Metabronema prevosti.* Posterior extremity of male.

In the female the anus is 50$\mu$ to 60$\mu$ from the blunt posterior end; the vulva is situated slightly posterior to the middle of the body. The eggs, oblong in outline, embryonated and measuring 48$\mu$ to 51$\mu$ by 25$\mu$ bear coarse filaments at either poles which are provided with knobs. In the male the posterior extremity (Fig. 2) is coiled and the anus is 0.12 mm. from its tip. The caudal alae are well developed and supported by papillae, of which four pairs are anterior to the cloaca and five pairs posterior to it. The two spicules are unequal in length. The left one is 0.8 mm. long in one specimen and 1.2 mm. in the other; the right spicule, much shorter and thicker measures 0.08 mm. in length in one specimen and 0.12 mm. in the other. No gubernaculum could be seen.

As shown in Table I, it is possible on the basis of the length of the spicules, the arrangement of the caudal papillae or the size of the eggs, to distinguish *M. prevosti* from other species of the genus. Thus by the size of the spicules it differs from *M. caranxi*, *M. iwana*, *M. fischeri*, *M. magna*, *M. salvelini*,

TABLE I

COMPARISONS OF FEATURES OF MEMBERS OF THE GENUS *Metabronema*

| Species | Total length | | Spicules | | Caudal papillae | | Size of eggs, $\mu$ |
|---|---|---|---|---|---|---|---|
| | Female, mm. | Male, mm. | Long, mm. | Short, mm. | Preanal, No. | Postanal, No. | |
| *amemasu* Fujita, 1939 | 21 | — | — | — | — | — | 70 × 50 |
| *caranxi* Tubangui *et al.*, 1937 | 65-70 | 19 | 1.16-1.25 | 0.34-0.40 | 4 | 5 | 42.7-45.7 × 24.5-5.26 |
| *fischeri* Travassos *et al.*, 1928 | 9.7-12 | 9.6 | 0.9-1.0 | 0.16-0.18 | 4 | 5 | 40-44 × 32 |
| *ishii* Fujita, 1939 | — | — | 1.10 | 0.10 | 10 | 3 | 79 × 35 |
| *iwana* Fujita, 1928 | 20 | 12 | 0.72 | 0.04 | 16 | 2 | 60 × 30 |
| *kosugii* Fujita, 1939 | 12 | 11 | 0.6 | 0.13 | 8 | 2 | 70 × 50 |
| *laticauda* Fujita, 1939 | 10.8 | — | — | — | — | — | 27 × 14 |
| *magnum* (Taylor, 1925) | 19.9 | 23.2-25.0 | 1.7-1.8 | 0.39-0.45 | 4 | 5 | 32 × 23 |
| *onchorhynchi* Fujita, 1939 | 18.5 | <18.5 | 1.14 | 0.8 | 10 | 3 | 34 × 13 |
| *prevosti* mihi* | 9.3-13.2 | 7 and 10 | 0.8 and 1.2 | 0.08 and 0.12 | 4 | 5 | 48-51 × 25 |
| *salvelini* (Fujita, 1920) | 8.6-15 | 6-7 | 0.24 | 0.117 | 4 | 6 | 50 × 27 |
| *skrjabini* Layman, 1933** | 8.2-8.9 | 6.1-6.5 | 0.378 | 0.067-0.094 | — | — | 43-45 × 24 |
| *wardlei* Smedley, 1933 | 45 | 22.2 | 1.85 | 0.2 | 2 | 5 | 27-41 × 30-40 |

* *Length of spicules of two specimens.*

** *Measurements on material from Onchorhynchus gorbuscha* Walb.

*M. skrjabini*, and *M. wardlei;* by the arrangement of the caudal papillae it also differs from *M. ishii*, *M. kosugii*, *M. onchorhynchi*, and by the size of the eggs from *M. amemasu* and *M. laticauda.*

*Type host:* *Ameiurus nebulosus nebulosus* (Le Sueur)

*Location:* Intestine.

*Locality:* Ottawa River (Ste. Anne de Bellevue, Jacques Cartier Co., Province of Quebec, Canada, July, 1939).

*Specimens:* Types, paratypes (five females and one incomplete male) at present in the helminthological collection of the Institute of Parasitology, Macdonald College, McGill University.

## The Genus *Metabronema*, Its Species and Their Distribution

In 1926, Yorke and Maplestone (25) created the genus *Metabronema* (Spirurinae) to receive *M. magnum* (Taylor, 1925) originally described under the name of *Habronema magna* (20). While several species have been since ascribed to this genus, its status, particularly in regard to *Ascarophis* van Beneden, 1871, requires clarification. Van Cleave and Mueller (23) suggest the possibility of synonymity between these two genera; Chitwood *et al.* (7, 8) consider them to be identical. Baylis (2) and subsequently Chitwood (6) have pointed out the close relationship of *Ascarophis* and *Spinitectus* Fourment, 1883. The latter genus is considered by Van Cleave and Mueller (23) to be so closely related to Cystidicoloides Skinker, 1931 as to almost justify synonymity. Van Cleave and Mueller (23) have suggested that *Cystidicoloides* is probably a synonym of *Metabronema* which Baylis (4) definitely considers to be identical with the former, a view also adopted by the writer. However, owing to the limited information available on *Ascarophis* the writer thinks that it is preferable, at least for the time being to consider it as a separate entity.

Since its inception, 13 species from fish hosts have been ascribed to this genus, to which Baylis (3, 4), has transferred the following species: *Cystidicola harwoodi* Chandler 1931, *Cystidicola* (*Pseudocystidicola*) *skrjabini* Layman, 1933, *Cystidicola fischeri* Travassos *et al.* 1928, and *Spiroptera salvelini* Fujita, 1920, which has already been transferred by its author (12) to the genus *Cystidicola.* The systematic status of the first and last of these species together with that of *M. canadense* Skinker, 1930 and *M. truttae* Baylis, 1935 has been discussed by Baylis (3) and the writer (10), who considers them to be synonymous. As shown by the writer (10) the name of a species originally described by Fujita (13) as *M. salvelini* being preoccupied was changed by its author to that of *M. ishii.* Fujita (13) reports the finding of *M. iwana* in *Salvelinus malma* from Lake Biwa, Japan. Unfortunately, Fujita does not state whether this species is the one he described (12) from the same host and locality under the name of *Cystidicola iwana;* however, after a search of the literature, the writer believes that this is the case.

As shown by the host list, species of the genus have been recorded in Australia, Brazil, Canada, England, Japan, the Philippines, Russia, and the United States of America. At present the majority of the species reported as belonging to the genus *Metabronema* has been found in salmonid fishes. From North American fish hosts two species in addition to *M. prevosti* have been recorded: *M. wardlei* Smedley, 1934 from a species of rockfish (*Scorpaenichthys marmoratus*) from Nanaimo, B.C and *M. salvelini* (Fujita, 1920) from trout and char from both the U.S.A. and Canada (Quebec and Labrador). The latter species was also found in material given to the author from an unidentified species of dace from Lake Edouard, Province of Quebec, and in the intestine of a single one out of over 200 maskallunge, *Esox masquinongy*, from the St. Lawrence watershed. The material from the maskallunge consists of only one male and one immature female; these data suggest that *Metabronema* is not normally parasitic in this host.

*The Geographical and Host Distribution of Species Attributed to the Genus Metabronema Yorke & Maplestone, 1926*

1. Australia

   *M. magnum* (Taylor, 1925) syn.: *Habronema magna* Taylor, 1925. In *Trochurus declivis*, *Sparus* sp., and *Caranx* (*Gnathonodon*) *speciosus* (20, 4).

2. Brazil

   *M. fischeri* Travassos *et al.*, 1928. In *Salminus maxillosus* (21).

3. Canada (Quebec, Labrador, and British Columbia)

   *M. salvelini* (Fujita, 1920) syn.: *M. canadense* Skinker, 1920, *Cystidicola harwoodi* Chandler, 1931, *M. truttae* Baylis, 1935. In *Salvelinus fontinalis*, *S. arctirus* (18, 17, 9, 10), species of dace (*) and *Esox masquinongy* (*).

   *M. wardlei* Smedley, 1933. In *Scorpaenichthys marmoratus* (19).

   *M. prevosti* nov. sp. In *Ameiurus nebulosus nebulosus* (*).

4. England

   *M. salvelini* (Fujita, 1920). In *Salmo truttae* (3).

5. Japan

   *M. amemasu* Fujita, 1939. In *Salvelinus kundscha* (13).

   *M. ishii* Fujita, 1939. In *Salvelinus kundscha*, *Onchorhynchus keta* (13).

   *M. iwana* Fujita, 1928. In *Salvelinus malma* (12).

   *M. kosugii* Fujita, 1939. In *Salvelinus kundscha* (13).

   *M. laticauda* Fujita, 1939. In *Onchorhynchus nerka* (13).

   *M. onchorhynchi* Fujita, 1939. In *Onchorhynchi maso* ("Yamabe") (13).

   *M. salvelini* (Fujita, 1920). In *Salvelinus kundscha*, *S. malma*, *Onchorhynchus nerka* (3, 12, 24, 13).

(*) Identified by the writer.

6. Philippines

*M. caranxi* Tubangui *et al.*, 1937. In *Caranx speciosus* (22).

7. Russia

*M. skrjabini* (Layman, 1933). In *Onchorhynchus gorbuscha, Thymallus articus, Cottocomephorus grewingki, Cottus kneri, Acipenser baeri* (16).

United States of America (New York State, Wisconsin, and Lake Erie tributaries)

*M. salvelini* (Fujita, 1920). In *Salmo gairndnerii, Salmo fario, Salvelinus fontinalis* (23, 5, 15, 14, 1, 11).

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# OBSERVATIONS ON THE BIOLOGY OF THE INFECTIVE LARVAE OF *STRONGYLOIDES AGOUTII*[1]

By Michael R. Reesal[2]

## Abstract

The larvae of *Strongyloides agoutii* are positively thermotactic, are stimulated by light, and although not actively attracted by it, remain in lighted areas reached by random. They survive moderate desiccation and can live for four weeks in tap water. They show a tendency to migrate in all directions, not only upwards.

The genus *Strongyloides* was created by Grassi (8) in 1879 for the human *Anguillula intestinalis* Normand, 1876. In this paper, the different forms of the parasite were first described. In 1882 Leuckart (11) demonstrated the variations in the life cycle. The peculiar alteration of generations of this nematode and its alternative free developmental cycles are now well known, although the mechanism responsible for controlling the directional growth of different forms from eggs to parasitic females is still not clear.

Comparatively little work has been carried out on the biology of these forms although Fülleborn (4, 5, 6, 7) in a series of papers published from 1914 to 1932 paid considerable attention to the infective larvae of *S. stercoralis*, while Sandground (16, 17, 18, 19) studied the life cycle and host specificity of the same species and Lane (10) and Sheldon (20) commented on several points of the behavior of the infective larva. All dealt with the human species.

The availability of *Strongyloides agoutii* of the agouti (*Dasyprocta agoutii*), a species which is also transmissible to the guinea pig, has enabled some studies to be made on the biology of the infective larvae of this species.

## Methods

Cultures were made by a modification of the method described by White (21).

Petri dishes of diameter 4 in. and 2 in. respectively were employed in these experiments. White's inner Petri dish was substituted for by the smaller Petri dish. Freshly collected agouti or guinea pig feces were mixed with charcoal moistened and crushed to the consistency of petrolatum, not flooded with water. Development of eggs from the agouti was indirect whereas from the guinea pig many of the eggs developed directly into filariform larvae although the indirect type still predominated. Accordingly a small amount of feces supplied several thousand infective larvae. The infective larvae

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migrating out of the culture were trapped in the water surrounding the smaller Petri dish. As the larvae could not break through the meniscus of water in the outer dish they were, therefore, unable to migrate further.

After 8 to 10 days about 15% of the larvae were collected in this way, free of gross fecal contamination. The greater part of the larvae remaining in the culture medium was collected by pouring about 6 to 10 cc. of warm water (40° C.) into the smaller Petri dish. Within two minutes the water was poured off and thousands of infective larvae were contained in a small volume of water. To reduce solution of fecal material during this process covering the medium with sand previous to decanting was very helpful.

A comparatively small recovery of infective forms was made with the Baermann apparatus. The reason for this will be discussed below.

## Reactions to Temperature

The term tropism is used to denote the reaction of a part of an organism to a stimulus and is therefore usually employed for sessile organisms. Taxis denotes reaction of the whole animal or plant to a stimulus and, with the exception of motile acellular plants, is confined to animals. Accordingly, taxis is preferred to tropism in the present discussion.

### (*a*) *Taxis*

Moderate heat stimulates nematodes to greater activity, as it will most organisms. Lane (10) believed that this was the extent of the heat effect on infective larvae, although Fülleborn (7) claimed that infective larvae of *Strongyloides* showed a definite positive thermotactic.

To investigate the reaction to higher temperatures on the infective larvae of *S. agoutii*, the following experiment was carried out using a simple and efficient technique for testing thermotaxis (1).

A heated needle was placed underneath a Petri dish containing infective larvae. They moved very definitely towards the heated point from all directions. Moving the needle from one position to another caused larvae to change their direction.

The sensitivity of these larval worms to heat stimulation emphasized the necessity of isolating this factor from light in experiments designed to investigate the effects of light.

The infective larvae of *S. agoutii* are strongly attracted to moderate heat; they are, therefore, positively thermotactic.

### (*b*) *Correlation of Temperature with (1) Larval Movements and (2) Thigmotaxis*

About 10,000 larvae were placed in a small Petri dish with saline to a height of about 2 mm. The infusion was heated slowly on a warm plate and the

temperature recorded by a thermocouple. The experiment was repeated several times.

15° C. and below: – larvae lie motionless at the bottom of the dish.

20°-28° C. : about 50% of the larvae moderately active but still quite lethargic.

28°-30° C.: – majority in motion; larvae display constant but moderate side to side movement. (This is not a lateral movement, but really dorsal–ventral although the animal moves in a horizontal plane.)

30°-37° C.: – very active; noticeable tendency to swim towards the edge of the dish and attempt to migrate outwards.

When larvae come in contact with an object in the infusion, especially a flocculent mass of debris, they push their heads inwards and with violent lashing movement appear to be boring through the object. The organisms often seem to use the tail as a fulcrum for pushing their way through. This behavior while it is sometimes noticed at lower temperatures is more frequent the nearer one approaches 37° C. The larvae always move more actively in contact with an object than swimming freely. In this respect the animal can be said to display a positive thigmotaxis, but there is, definitely, a correlation between temperature and reaction to solid objects.

40°-55° C.: – larvae move violently and spasmodically.

Above 55° C.: – larvae lie straight out as if dead but can be revived by cooling if the temperature does not exceed 80° C.

## Reactions to Light

Both van Durme (3) and Looss (12) refer to the remarkable migratory instinct in *S. stercoralis* finding that larvae are prone to climb the walls of culture dishes equally under dark and lighted conditions. Fülleborn (5) does not find any phototaxis in *Strongyloides*. Rogers (15) from a study of the relation between light of various intensities and larval migration has shown that while most trichostrongyle larvae migrate at a light intensity of 62 ft-c., those of *S. papillosus* do not seem to be affected very much by light.

When numbers of larvae of *S. agoutii* were placed in a Petri dish, with the temperature at about 23° C., they always accumulated very slowly at the more lighted side. This could be reasonably accounted for in one of two ways:

(1) Larvae were positively attracted to light.

(2) During the course of random movement, once arriving at the lighted area they did not move out, showing an avoidance to darker areas.

In order to isolate the effect of light, half of a Petri dish was blackened. The majority of larvae was found in the lighted half after 30 min.

From the time taken by larvae to accumulate in the lighted half and from direct observation it appeared that the second possibility was the more probable, namely, that the larvae were not attracted directly to light but during their random movement stayed in more lighted areas.

When larvae were in water below 23° C., many settled on the bottom of the dish and lay dormant. If a flash of light were directed in the region in which they were lying, after about a minute the larvae revived completely; at first they twisted, then the horizontal lashing became more evident. Eventually they swam off without apparently "choosing" any direction, usually moving off in the direction in which their head end had pointed while they were lying dormant.

This observation was repeated time and again using the mirror of the microscope to produce the flash of light.

Infective larvae, therefore, are stimulated by light but do not move actively towards lighted areas although they will accumulate there. In nature, they could reach these areas by being attracted to heat or during the course of random movement.

## Effect of Desiccation

Kreis (9) confirmed the work of Darling (2) and Fülleborn (4), both of whom showed that the resistance of *Strongyloides* to desiccation was very slight.

When an infusion of infective larvae was placed in a drop of water on a slide, the larvae showed a great tendency to swim to the edge of the drying drop, often extending the water boundaries outwards and increasing the rate of evaporation. In a while, a thin film of water persisted around each larva, but almost coincident with the disappearance of this film the infective larva died. Flushing with water or saline did not revive it although the larva did reassume its characteristic shape and size in the majority of cases.

In a saturated atmosphere, however, larvae survived unharmed.

Fecal cultures known to contain infective larvae were allowed to dry by preparing the culture in a small Petri dish, with the lid on but with no filter paper to retain moisture, and leaving the whole under room conditions. During the winter months, when the humidity of the laboratory was very low, such cultures dried slowly. Infective larvae were dead when the culture was so hard that pressing upon it with a wooden applicator did not make any surface impression. However, as long as an impression could be made, infective larvae were alive. Many cultures appeared dry but the presence of a little moisture was sufficient to sustain life. Using apparently dry soil for testing the ability of larvae to withstand desiccation often gives misleading results.

## Reaction to Humidity and Surface Tension

True hydrotaxis which implies a positive attraction to water, is very hard to prove since larvae must primarily be in water, be it only a microscopic film. Infective larvae do not show any positive movement towards water

when they are in a drying suspension; rather in a drying drop they persist on the outer periphery, ever pushing themselves outward as far as they can go until completely desiccated.

Lane (10), on theoretical grounds, thought that it was not possible that larvae could display hydrotaxis, positive or negative, because ". . . . . an animal enclosed in water as a condition of its life can hardly have a taxis to a body of water outside. . . . ." Fülleborn (7) although offering no positive evidence for the presence of absence of this tropism, disagreed with Lane.

Fülleborn (4) stated that all infective larvae of *Strongyloides* die after 24 hr. in tap water. He obtained the longest survival (seven days) in the aquarium. Kreis (9) confirmed his results.

About 15 cc. of water was poured into a Petri dish, covered, and placed in a warmer room (incubator 37° C.). When brought to a lower temperature (23° C.) at which the experiment proceeded. Moisture collected in small droplets on the lid of the dish. A heavy suspension of larvae was placed on the inner side of the lid surrounded by these irregular condensation drops. The whole was observed with a binocular dissecting microscope. Larvae migrating from one drop showed no 'choice' in their course, wandered at random, and in most cases migrated to another drop by sheer accident. Outside of a drop, their typical dorsoventral (i.e. horizontal) lashing explored a wider path than would have been possible by straight movement. Once inside the drop a straight course was pursued until they reached the other edge; immediately, the frequency of their lashing movements increased, with the body remaining at right angles to the surface of the drop. Should the water droplet containing the larvae be deep and large (depth – twice body length; diameter – about four times body length), some of the larvae soon fell to the bottom and lay dormant in a straight position. Stimulation by light, heat, shaking, or rapid evaporation revived the larvae.

If the temperature was again raised to 37° C. larvae were able to travel more effectively from one drop to another and the tendency to lie dormant was reduced to the vanishing point.

When the condensation drop was not deep (less than twice the width of the larvae) they readily broke through the meniscus.

As mentioned above, the recovery of infective larvae in the Baermann apparatus was comparatively low. When a heavy, clear suspension of larvae was placed in a funnel filled to within one-half inch of the upper edge with water (38° C.) only a small proportion fell to the bottom of the funnel; most of the larvae were around the edge of the water, where they could remain for several hours.

On a slide coated with a thin film of petrolatum a single larva was placed in a drop of water. The water could not spread over the slide and the larva was trapped within the drop, incapable of breaking the meniscus and escaping. This was in contrast with the case in which the drop of water was on a clean surface when the water itself had a tendency to spread. The activity of the

larva was much increased in an enclosed droplet. This increase in action was also noticed whenever the anterior end of the organism came in contact with any solid object or barrier.

Unlike *Strongyloides stercoralis* (Fülleborn (4) and Kreis (9) ) larvae of *S. agoutii* remained alive for as long as 28 days in tap water. They were left in a Petri dish open to the air with a minimum of water, tap water being added regularly to prevent drying. Not only did the larvae survive but when inoculated percutaneously they produced an infection.

## Migration of Larvae

Van Durme (3) observed a remarkable tendency of infective larvae to migrate. Looss (12) later recorded this property in various species of Ancylostomes, noting also that it was independent of light. Subsequent workers while recognizing the presence of some inherent tendency for infective larvae to be more exploratory than the younger forms, attempted to explain most movements on the basis of some specific taxis. That larvae are sensitive to certain stimuli is shown by the experiments outlined previously, but given favorable conditions such as a saturated atmosphere and weak diffuse light, larvae will migrate at random, this tendency can proceed in the absence of any directional stimulus. The infective larvae of *Strongyloides* are quite active and undoubtedly temperature and light gradients on leaf blades play a large part in deciding the place where a greater concentration of infective larvae would be found.

Payne (13) working with larvae of *Necator americanus* claims that while the larvae are in a film of water, geotaxis can be neglected. Rees (14), in an intensive ecological study of the third stage larva of *Haemonchus contortus*, shows that, under saturated conditions suitable for larval migration, upward movement is usually due to attraction to heat or light.

It is doubtful whether true geotaxis plays any part in the upward migration of *S. agoutii*. In culture dishes described above in which larvae were present in a small Petri dish, the whole enclosed within a large Petri dish, a certain percentage (varying between 5% and 20%) of the larvae migrated up the sides and down again to be caught in the surrounding water trap. These larvae therefore moved upwards, then downwards.

From the present observations on *S. agoutii* and those of van Durme (3) and Looss (12) on *S. stercoralis* it seems that upward migration can be accounted for by the inherent tendency of infective larvae of *Strongyloides* to migrate in all directions once the conditions are favorable. With increased temperature this tendency is more marked, the larvae being much more active at temperatures above 28° C.

The percentage of infective larvae of *S. agoutii* that migrate upwards compared with those that travel laterally suggests that the larvae have no predilection for strict upward movements.

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# OBSERVATIONS ON THE DEVELOPMENT OF *STRONGYLOIDES AGOUTII* OF THE AGOUTI IN THE GUINEA PIG[1]

By Michael R. Reesal[2]


## Abstract

The development from infective larva to adult female of *S. agoutii* in the guinea pig is described. In this animal the adult worm lives only for six weeks, the host becoming immune after this period. Egg production is much more rapid than in the agouti in which animal the parasite has a life of over a year.


Few studies have been made on the development of the infective larva of *Strongyloides* into the functional male. In fact, the only detailed description of immature phases appears to be that of Faust (1) who dealt with *S. stercoralis* of man. The availability at the Institute of Parasitology of a species of *Strongyloides* (*S. agoutii*), which can be transferred successfully to the guinea pig, has enabled the writer to make a similar study of a second species of this genus.

Cultures were made and infective larvae isolated as described in a previous paper (3). Guinea pigs were infected both percutaneously and orally.

The infective larva of *S. agoutii* varies in length from 0.61 to 0.76 mm. with an average width of 0.20 mm. Only a small proportion of the larvae are able to penetrate the skin of the guinea pig. Thus, the number reaching maturity after percutaneous inoculation is 12 to 16%, whereas the number reaching maturity after oral administration, in which the larvae are given ample opportunity to bore the lining of the mouth, is 22%.

The larvae seem to undergo no change after penetration. It is improbable that a molt takes place at this stage as there seems to be no change in the behavior or morphology; after skin penetration no shed cuticle can be seen, and many larvae that penetrated the skin could do so again. The percentage (40%) that penetrate again is much higher than that which occurs in a population of larvae recently taken from culture (12 to 16%). Sheldon's work with *S. ratti* of rats (4) shows that subcutaneous inoculation is, on the average, consistently 13% higher than percutaneous inoculation and about 3% higher than when larvae are allowed to penetrate the pregastric mucosa.

Larvae, inoculated simultaneously, do not all travel together but reach the intestine over a long period and can be found throughout the entire migratory tract from 48 hr. to over eight days after infection. However, between 72 and 96 hr. after inoculation most larvae of *S. agoutii* can be found beyond the lungs and are already settled in the intestine.

[1] *Manuscript received November 22, 1950.*

*Contribution from the Institute of Parasitology, Macdonald College, McGill University, Macdonald College P.O., P.Q., Canada, with financial assistance from the National Research Council of Canada.*

[2] *Junior Research Assistant.*

Faust (1) recovered larvae of *S. stercoralis* from the heart of a dog on the 30th day after inoculation. He believed that the larvae were retained in the skin during this period.

Larvae enter the venous blood stream at a point which depends upon the site of inoculation and are carried to the heart and to the lungs. They can be recovered from the heart as early as 12 hr. after inoculation.

In one instance, a larva in the process of molting was recovered from the lungs 36 hr. after inoculation; such a larva must be a fourth stage one. There is good evidence that this molt is usual and not accidental, as the larvae that leave the lung are very different in their behavior from those usually recovered from the heart. These are usually unchanged infective larvae showing the typical lashing movement whereas those obtained from the lungs and farther down the migratory tract coil in and out, hardly ever "swimming," but moving by wriggling movements. In their morphology they do not seem to have changed, the only readily discernible difference being that of movement.

At this stage, larvae can pass successfully through the stomach and implant themselves in the intestine so that during this molt they must undergo profound changes in their physiology. They have lost the ability to bore through the skin, have no tendency to escape from the alimentary canal into the blood stream, and have acquired the ability to survive passage through the stomach and settle in the intestine.

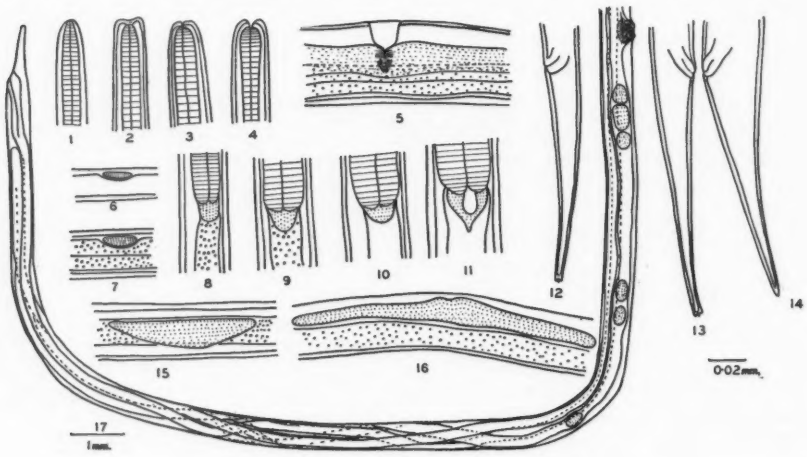
## The Fourth Stage Larva

In the postfilariform larva, the head, which was more or less conical in shape (Fig. 1), becomes blunt, gradually flattening out owing to the growth of a thick outer wall which appears gradually throughout the body. The outer thickening advances anteriorly and for a while one may notice the typical shape of the anterior end being covered over (Fig. 2). At this stage, the mouth appears to have a buccal cavity but this is due merely to the incompletely developed anterior end. Fig. 3 shows the head end in its final shape of this stage.

The genital primordium shows a definite increase in size with the increase in length of the larva. During this stage the genital primordium increases in size but does not show any structural differentiation. Fig. 6 shows the genital primordium as it appears in the infective larva. In Fig. 7 the larva has a total length of 0.969 mm. Fig. 15 shows the genital primordium when the larva has a total length of 0.991 mm.

A group of cells appears at the junction of the oesophagus and intestine, proliferating rapidly at first to form an oblong structure between the oesophagus and intestine (Fig. 8). Later, on the side of the bud towards the oesophagus, the structure widens in keeping with the gradually increasing width of the oesophagus itself (Fig. 9). The oesophageal width at the junction of the intestine increases from 0.014 mm. at the beginning of this stage to about 0.019 mm.–0.022 mm. at the end.

During this entire process, the tail retains its original shape and characteristic ending (Fig. 12). In keeping with the general increase in width the tail shows a corresponding increase in its thickness and a very slight increase




FIGS. 1-17. *Strongyloides agoutii.*

FIGS 1-4. Development of head end. FIG. 5. First appearance of vulva. FIGS. 6, 7, 15, 16. Development of ovary. FIGS. 8-11. Development of oesophageal–intestinal junction. FIGS. 12-14. Changes in tail ending. FIG. 17. Posterior part of parasitic female showing coils of ovary.

in length of the order of 0.01–0.02 mm. (Fig. 13). The tail in later stages does not increase in length; it has reached its maximum, 0.097–0.109 mm., at the close of this stage, and all further increase in size is manifested in increasing thickness.

From an average length of 0.710 mm. and width of 0.020 mm. the larva grows to 1.020 mm. and 0.026 mm. Primordial spicules and gubernaculum noted by Faust (1) were not observed in this study nor were any stages suggestive of a parasitic male encountered.

When the larva reaches a size of about 1 mm. it undergoes its last molt in the host.

## The Developing Adult

The most obvious feature in development after molting is a rapid increase in width, although increase in length is slight. Later, however, the rate of growth in length increases while that in width decreases.

Another "ring of growth" widens the worm and in the anterior end the appearance of a false buccal cavity is again apparent. Faust's figures of developing males of *S. stercoralis* in which a buccal cavity is pictured could perhaps be accounted for on the basis of this characteristic growth. Fig. 4 shows the appearance of the anterior end in a worm which is 2.70 mm. long.

The most striking feature of this period is the rapid development of the female genitalia. At the end of the postfilariform stage the genital primordium is slightly developed (Fig. 15). At the original site of the genital primordium the developing organ becomes saddle-shaped, the proliferating ends (Fig. 16) extending anteriorly and posteriorly respectively. A gradual dorsal curving of the extending arm appears when the ovary reaches a total length of about 0.2 mm. in a worm 1.13 mm. long. The anterior and posterior ends are definitely curved in opposite directions.

When the worm reaches a length of 2.7 mm., a wide slit appears at the point of original proliferation (Fig. 5). This marks the position of the vulva. Later, this cavity extends within and uterine characteristics become evident.

The anterior loop of the ovary extends to 1.0 mm. from the oesophagus and the posterior loop 1.0 mm. from the anus. Further increases in length result in coiling of the ovary around the intestine. In the full grown ovary there are two turns posteriorly. Except for one twist in the loop there are usually no complete coils anteriorly in this species.

The appearance of the ovary is largely dependent upon the stage of development. After the worm has been expelling eggs for some time the boundary of the uterus extends until finally there is nothing but a series of tubes.

Although the postoesophageal bud at the oesophageal–intestinal junction does not grow consistently after the last molt, in some cases it appears to be hollow (Fig. 11). In other cases it persists within any apparent vacuole (Fig. 10). The development of this bud and its persistence in the adult female probably represent remnants of an ancestral postoesophageal bulb.

The overall increase in size in this step is very great. The worm, measuring 0.102 mm. in length and 0.026 mm. in width at the beginning, reaches a length of 5.170 mm. and a width of 0.044 mm.

## Life Span of the Parasitic Female

After about six weeks, the guinea pig loses its infection of *S. agoutii* and has built up an immunity to further infection (2).

If a guinea pig is autopsied between three and four weeks after infection, the females that are recovered are already effete. All the eggs seem to have been expelled from the ovaries. The worms become detached after their eggs are extruded and are themselves voided.

However, in the normal host, the agouti, infection lasts for more than one year. One animal brought from the wild had a very good egg output for about nine months, after which time there was a noticeable fall in eggs found in the feces. The output appears to be more gradual and extends over a longer period. It is not known whether immunity is conferred after the animal is freed of infection.

A heavily infected guinea pig yields a prodigious amount of eggs. One pellet of feces when crushed in water and examined directly shows hundreds of eggs. This egg production falls off rapidly after two and one-half weeks.

The reason for the more rapid egg production of *Strongyloides agoutii* in the guinea pig than in the agouti is not known.

In the majority of cases the organism does not seem to disturb its abnormal host, the guinea pig, to any great extent. The animals gain weight and appear to be just as active as uninfected guinea pigs.

However, on three occasions infected guinea pigs died suddenly without showing any symptoms of sickness before death. In all three cases, the animals were of average weight and did not display any symptom of intestinal disturbances. They died usually about a month after infection and on post-mortem only a few effete worms were recovered.

Similar sudden deaths have been observed in rabbits infected with *S. papillosus* which is normal to the sheep.

In sections made of the intestine of a heavily infected guinea pig parasites were noticed only in the mucosa. In no case were worms found in the submucosa. Usually they were embedded just beneath the layer of columnar epithelium.

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# AN ANNOTATED LIST OF THE LEPIDOPTERA OF ALBERTA[1,*]

By Kenneth Bowman[2]

## Abstract

This list consists of 1825 species and varieties of Lepidoptera which have been taken in Alberta. Of these, 657 are records of captures in the hitherto almost completely neglected Microlepidoptera. Though few specialists on this continent have studied the taxonomy of this large group, those who have done so in certain families have generously assisted in classifying the species which are recorded. Unfortunately, in a few families it has been impossible to obtain this assistance. Despite the omissions this necessitates, the list constitutes the most comprehensive catalogue of Microlepidoptera which has, up to the present, been attempted for any province in the Dominion.

Arrangement and nomenclature are based on McDunnough's *Check List of the Lepidoptera of Canada and the United States*, published in 1938 and 1939. Proposed modifications in nomenclature, presented in subsequent publications, are substituted if they appear to be gaining general acceptance.

Locality records for captures are presented by a system of ecological areas of which the chief climatological and biological characteristics are briefly described.

## Introductory

Professional entomologists are very greatly aided in the pursuit of their lifework with its practical objectives by the unstinted and critical industry of competent amateurs. Such amateurs have gathered a vast mass of data upon the distribution and the relative abundance of various insects and have recorded valuable information on the biology of the groups to which they have devoted their particular attention. In no field of entomological endeavor has this been more in evidence than it is in the study of Lepidoptera.

The province of Alberta is fortunate in that its residents have included a number of lepidopterists of unusual industry and ability. The pioneer in this field was F. H. Wolley-Dod, whose material now forms part of the Canadian National Collection in Ottawa. Other active Albertan lepidopterists have included D. Mackie of Edmonton, G. Sanson of Banff, H. Baird of High River, O. Bryant, and P. F. Bruggemann.

In 1904, Kenneth Bowman, who already possessed a thorough working knowledge of the Macrolepidoptera of England, started to collect energetically in the vicinity of Edmonton and in several of the mountain passes. He soon turned his attention to the almost universally neglected Microlepidoptera. In both quality and quantity his collection in the latter group constitutes by far the most important contribution to a knowledge of these little understood Lepidoptera ever assembled in a private collection in Canada.

[1] *Manuscript received in original form March 20, 1950, and as revised, November 29, 1950.*

[2] *Edmonton, Alta.*

* *With introductory sections by E. H. Strickland, University of Alberta, Edmonton, Alta.*

In 1913, the writer established a light-trap at the Dominion Entomological Laboratory at Lethbridge. This has, subsequently, been in almost continuous operation during the summer months. Mr. Bowman has drawn upon the records of material obtained by it and has also been lent both reared and captured material from the recently established Forest Insect Laboratory at Seebe, on the outskirts of Banff National Park.

All specimens of which the identification was in doubt were submitted to Dr. J. H. McDunnough, Chief Curator of the insect collection at Ottawa. At the date of his retirement, he had completed a study of the Microlepidoptera to as far as the Tortricidae. In 1939, Dr. Annette Braun generously agreed to examine representatives of the remaining families. Her valued assistance has resulted in the addition of approximately forty new records for this province. Many of these had not, previously, been known to occur in Canada. There remain, however, some 50 to 70 unnamed species, chiefly in Phaloniidae, Gelechidae, Blastobasidae, Coleophoridae, Gracillaridae, and Tineidae. Dr. Braun indicates that a number of these are, as yet, undescribed.

An early draft of this list was submitted to Dr. T. N. Freeman in Ottawa. He proposed certain changes, which are indicated below, and he inserted a number of hitherto unpublished records of additional species from the files of the Ottawa collection.

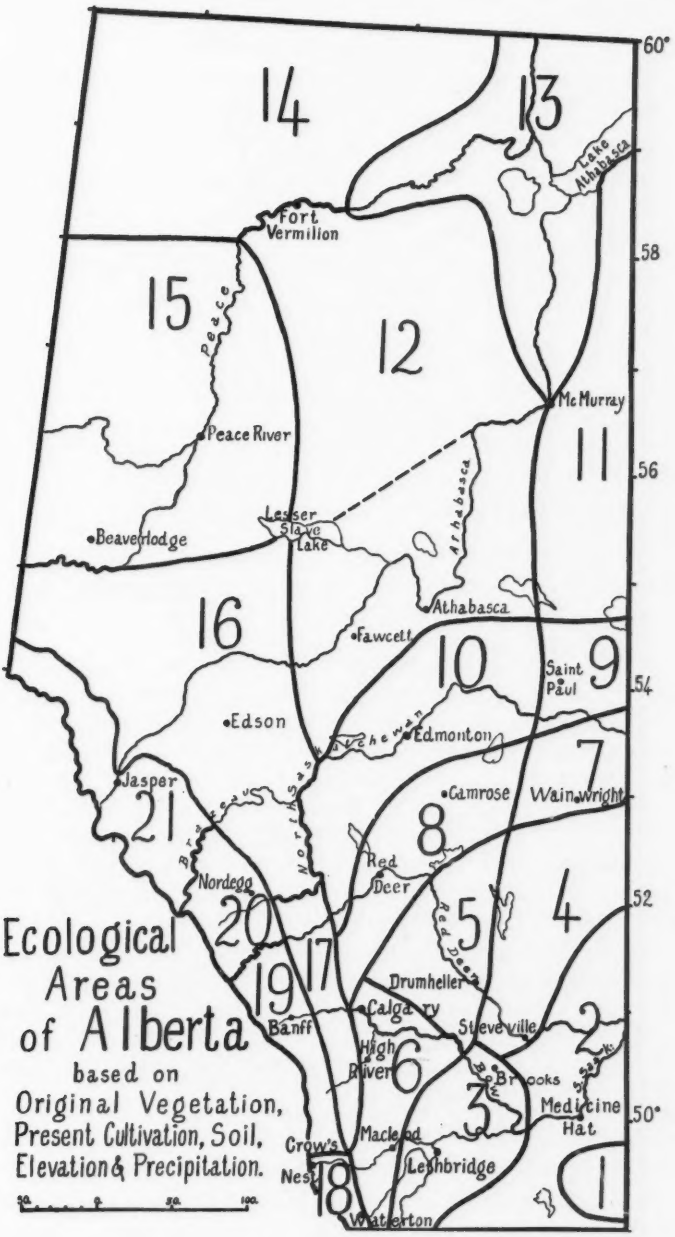
Records from sources which are considered to be of doubtful authenticity have been sedulously excluded from this list and it can, therefore, be accepted as the most complete and up-to-date catalogue of the species of Albertan Lepidoptera which could be compiled at the date of its preparation.

## Method of Listing Species

The following list is based on McDunnough's *Check List of the Lepidoptera of Canada and the United States of America* (14). Since the appearance of this publication, revisions of various groups have suggested modifications in the nomenclature employed in certain families and genera. Dr. Freeman, with the assistance of Mr. D. F. Hardwick and Mr. E. G. Munroe, has generously evaluated the significance of all such proposals and has indicated those which appear to be gaining general acceptance. All such changes have been incorporated and a reference to the authority for each is given in the bibliography. The numbers which were allocated to individual species by McDunnough have, however, been retained.

## Ecological Areas in Alberta

In recording localities in which captures have been made, Mr. Bowman has adopted the system of dividing this province into the 21 "Ecological Areas" which were defined and described by the writer in his *Annotated List of the Diptera of Alberta* (21). These are redefined herewith, and the map is reproduced without modification.


Ecological Areas of Alberta
based on Original Vegetation, Present Cultivation, Soil, Elevation & Precipitation.
14
13
15
12
11
16
10
9
21
8
7
20
17
19
5
4
6
3
2
18
1
Fort Vermilion
Lake Athabasca
Peace River
McMurray
Beaverlodge
Lesser Slave Lake
Athabasca
Fawcett
Saint Paul
Edson
Edmonton
Jasper
Camrose
Wainwright
Red Deer
Nordegg
Drumheller
Calgary
Banff
Stevesville
High River
Brooks
Medicine Hat
Crow's Nest
Macleod
Lethbridge
Waterton
60°
58
56
54
52
50°

*Transition Zone*

1. *Cypress Hills*

Vegetation: – About 50% forested; lodgepole pine, spruce, aspen, and willow. Remainder; long grass. Very little cultivation.

Elevation: – Up to 4500 ft.

Soil: – Very dark brown. Summit of hills, which is an extensive tableland, was never glaciated.

Rainfall: – 10-11.5 in.

Remarks: – Flora and fauna are very similar to those of Area 18. Few Lepidoptera have been collected in this area.

2. *Southern Prairie (Dry) (Medicine Hat)*

Vegetation: – Short grass. A few poplars, willows, and a variety of bushes in river bottoms. Cactus and sage are common, while a few yuccas can be found in the extreme south. Crops: chiefly grain. Deserted land has grown up to mustard and Russian thistle.

Soil: – Fine brown clay, inclined to be sandy in eastern half.

Rainfall: – Less than 10 in.

Remarks: – The fauna includes scorpions, solpugids, termites, horned toads, kangaroo rats, and rattlesnakes. Nowhere else, east of the Rocky Mountains, do these forms extend to the Canadian prairies. Among the comparatively few Lepidoptera which have been examined from this area several are of unusual interest. In other orders of insects, "desert" types appear to predominate and it is anticipated that more extensive collecting in Lepidoptera will produce a number of additional xerobiotic species.

3. *Southern Prairie (About 50% Irrigated) (Lethbridge)*

Resembles Area 2. Vegetation on dry areas similar, but irrigated parts carry a greater variety of crops, among which alfalfa and beets predominate. Both soil and rainfall are a little heavier.

Remarks: – Extensive collections of Macrolepidoptera, particularly in the Phalaenidae, have been made in the vicinity of Lethbridge.

4. *Northern Prairie (East) (Steveville)*

Vegetation: – Short to moderate long grass. Much deserted land. Crops: almost entirely grain.

Soil: – Dark brown loam.

Rainfall: – Less than 10 in. Very light in eastern half.

Remarks: – Hardly any Lepidoptera have been collected from this Area. The most extensive "badlands" of the Red Deer river are located here.

*Transition Zone*—Concluded

5. *Northern Prairie (West) (Drumheller)*

Vegetation: – Moderately long grass. Crops: grain.

Soil: – Heavy clay "gumbo" to dark brown loam.

Rainfall: – 10-11.5 in.

Remarks: – Collections of Lepidoptera have so far been confined to a few species which occur in a western extension of the badlands in which is situated the town of Drumheller. Among these are several which have not been taken elsewhere in the province.

6. *Northern Prairie (Southwest Extension) (Calgary)*

Vegetation: – Moderately long grass, occasional groves of willow and aspen. About 60% under cultivation. Crops: grain and hay.

Soil: – Dark brown loam.

Rainfall: – 10-11.5 in.

Remarks: – Very extensive collecting in Macrolepidoptera was conducted by Wolley-Dod in the northern half of this area but there has been little elsewhere.

*Intermediate Between Transition and Canadian Zones*

7. *Parkland (East) (Lloydminster)*

Vegetation: – About 30% wooded; aspen and willow groves, most heavily in northern half; remainder, moderately long to short grass. Crops: grain and some hay.

Soil: – Dark brown loam; some areas, however, are almost pure sand.

Rainfall: – Less than 10 in.

Remarks: – Mr. P. F. Bruggemann has collected Lepidoptera extensively in this area. He considers that our map should be modified by moving the boundary between Areas 7 and 9 to the North Saskatchewan River, and by transferring the more sandy areas around Wainwright to Area 4. It is unfortunate that neither Lepidoptera nor insects in other Orders have ever been extensively collected between Medicine Hat and Lloydminster. It would appear that many southern forms which, in the past, have been considered to be peculiar to the former area extend northward into this Area, though they show no signs of a similar northward extension anywhere further west.

8. *Parkland (West) (Red Deer)*

Vegetation: – Originally about 50% wooded; mainly aspen. Remainder, long grass. Now about 70% cleared. Crops: grain and hay.

Soil: – Dark brown loam.

Rainfall: – 10-13 in.

Remarks: Moderately intensive collecting has been conducted by Mr. Bowman in the vicinity of Red Deer.

*Canadian Zone*

9. *Poplar (East) (Saint Paul)*

Vegetation: – Originally, aspen, balsam poplar, and willow, with some spruce. Less that 50% cleared. Crops: chiefly oats.

Soil: – Black loam.

Rainfall: – About 10 in.

Remarks: – Mr. Bruggemann has collected some of the Lepidoptera which occur along the eastern boundary of this area.

10. *Poplar (West) (Edmonton)*

Vegetation, as No. 9, larger local stands of spruce and pine. About 70% cleared. Crops: wheat and oats, some hay, particularly clovers.

Soil: – Black loam, with high humus content.

Rainfall: – Over 13 in.

Remarks: – Mr. Bowman and Mr. Mackie have collected Lepidoptera extensively in this area, both around Edmonton itself and at several lakes up to about forty miles to the west of the City.

11. *Mixed Forest with Eastern and Subarctic Intrusions*

Vegetation: – Poplar, spruce, pine, fir, tamarack, willow, birch, and alder.

Soil: – Gray wooded, large areas of sand.

Rainfall: – Probably 10-11.5 in.

Remarks: – No insects have, as yet, been collected here.

12. *Mixed Forest with Cordilleran (Rocky Mountain) Intrusions (Fawcett)*

Vegetation: – Similar to Area 11. Numerous lakes and large areas of muskeg. A little cultivation in the south. Crops: chiefly oats.

Soil: – Gray wooded, very variable in texture.

Rainfall: – 11.5 to over 13 in.

Remarks: – There appear to be no factors on which this large area can be subdivided though we have, provisionally, inserted a broken line to separate it into "subareas". Only an occasional specimen of Lepidoptera has been seen from this area.

13. *Mackenzie Lowlands*

Vegetation: – Mixed forest, as No. 11, more Alpine–arctic species. Long grass and sedges in open spaces. No cultivation.

Soil: – Incompletely surveyed, probably all gray wooded.

Rainfall: – No record, probably about 13 in.

Remarks: – No Lepidoptera have been seen from here.

*Canadian Zone*—Concluded

14. *Mixed Forest with Some Parkland and Alpine–Arctic Intrusions*

Vegetation: – Resembles Nos. 12 and 15. No cultivation.

Soil and vegetation: – No accurate data.

Remarks: – Very few Lepidoptera have been sent in from here.

15. *Mixed Forest and Parkland (Beaverlodge)*

Vegetation: – Large mixed forest areas interspersed with long-grass open plains. Crops: chiefly grain and hay.

Soil: – 10-15% black loam; much gray wooded, scattered patches of sand.

Rainfall: – 10-13 in.

Remarks: – Small collections of Lepidoptera have been made in various parts of the Peace River District. In common with insects in other Orders, these appear to be almost identical with the general fauna of the Edmonton area.

*Foothill Zone*

16. *Foothills (Northern) (Edson)*

Vegetation: – Merges from that of No. 11 to that of 21. Incompletely surveyed. Some hay and grain in eastern half.

Soil: – Gray wooded. Believed to be very variable.

Rainfall: – Over 13 in.

Remarks: – A little collecting has been accomplished near Edson, but the fauna, in general, is not well known.

17. *Foothills (Southern)*

Vegetation: – Aspen, spruce, lodgepole pine, and willow, with much open prairie towards the southern end.

Soil: – Gray wooded in north merging to dark brown in the south.

Rainfall: – 13 in. in northern part but less than 10 in. in south.

Remarks: – This is the least uniform of the areas selected. Wolley-Dod collected Lepidoptera extensively in its center, particularly to the west of Midnapore in the foothills about 40 miles southwest of Calgary. Elsewhere the fauna is not well known.

*Mountain Zone*

The four areas into which this zone is divided each include a district in which moderately intensive collections of Lepidoptera have been made.

Vegetation: – This naturally varies greatly. Montane territory is dominated by lodgepole pine and white spruce. Douglas fir is locally abundant. Subalpine territory is characterized by Engelmann spruce, alpine fir, and other conifers, as well as by mountain heaths.

From Area 18 to Area 21 there is a gradual replacement of southern and western species by certain boreal and arctic species.

*Mountain Zone*—Concluded

18. *Southern Rocky Mountain (Waterton and Crow's Nest Pass)*

Vegetation: – Strong intrusions of southern and western species extend to about the northern limits of this area.

Soil: – Has a higher lime content than have the more northern mountain areas.

Rainfall: – Over 13 in.

Remarks: – Spasmodic, but not intensive, insect collecting has been conducted in Waterton National Park for many years. Dr. McDunnough devoted a summer there to the Pterophoridae and other Microlepidoptera. Much of his material was classified by Dr. Braun. Mr. Bowman has collected Macrolepidoptera intensively in the Crow's Nest Pass. The fauna of both districts appears to be very similar.

19. *Central Rocky Mountain (Banff)*

Vegetation: – Typical for entire mountain zone with few southern or Arctic intrusions.

Soil: – Though very variable is, generally speaking, of a gray wooded type.

Rainfall: – Over 13 in.

Remarks: – Though many visitors have made small collections in this National Park, the only consistent collector of Lepidoptera was the late Mr. G. Sanson, for many years curator of the local insect collection. With the establishment of a Dominion Forestry Laboratory at Seebe, knowledge of the distribution and the biology of the Lepidoptera in this area should rapidly increase.

20. *North Central Rocky Mountain (Nordegg)*

Vegetation: – Similar to that of 19 but the late Dr. Malte, Dominion Agrostologist, found, among the grasses, several species which had been considered as confined to Labrador growing in the vicinity of Nordegg.

Soil and rainfall: – As in Area 19.

Remarks: – For many years, Mr. Bowman collected Lepidoptera intensively in the vicinity of Nordegg. Here, too, he had taken many species of moths which had, formerly, been considered as peculiar to the Labrador fauna. None of these have been taken, either to the north or the south, in the Rocky Mountains.

21. *Northern Rocky Mountain (Jasper)*

Vegetation, soil, and rainfall: – As in No. 19, but with strong intrusions of arctic and boreal species.

Remarks: – Though several collectors have made sporadic collections of Lepidoptera elsewhere in Jasper Park, by far the most intensive are those of Mr. Bowman at Pocohontas, which is about twenty miles east of Jasper townsite.

Collections of Lepidoptera have rarely been made at a distance of more than about 50 miles from the town named (in brackets) in the above headings. Occasional specimens, taken elsewhere in these areas, have invariably belonged to the species which are known to occur in the neighborhood of these towns. Should it be desired to refer to a definite locality, in connection with any particular species, the name of the town can be safely employed as an alternative to the number of the Area in which it is located.

Arabic numerals which follow each insect name refer to the Ecological Area in which the species is known to occur. Roman numerals refer to the months in which the *adults* have been taken.

E. H. STRICKLAND,
University of Alberta.

## Suborder FRENATAE

### Superfamily PAPILIONOIDEA

#### PAPILIONIDAE

6 **Papilio** bairdii Edw. 8. VI.
" brucei Edw. 8, 10. VI.
7 nitra Edw. 2, 6, 8, 10, 18, 20. V-VII.
8 zelicaon Luc. 8, 18, 20, 21. VI-VII.
9 machaon dodi McD. 2, 5, 20. VII.
" hudsonianus Clark. 13, 20. VI-VII.
15 glaucus canadensis R. & J. 6-8, 10, 12, 18, 20, 21. V-VI.
17 daunus Bdv. 18. VI.
18 eurymedon Luc. 18. VI-VII.

27 **Parnassius** smintheus Dbl. & Hew. 17-19, 21. VI-VIII.

#### PIERIDAE

34 **Anthlocharis** sara stella Edw. 18. VI.

35 **Euchoe** creusa Dbl. & Hew. 12, 18-21. VI-VII.
36 ausonides coloradensis Hy. Edw. 6-8, 10, 18-21. V-VII.
37 olympia rosa Edw. 2. V.

38 **Colias** meadi elis Stkr. 19, 21. VII-VIII.
39 hecla glacialis McLach. 12, 20. V-VII.
" pallida Skin. 20. V-VI.
41 eurytheme Bdv. 2, 6-8, 10, 12, 15, 18, 19. V-IX.
" alba Stkr. 6, 7, 10. VI-VIII.
" amphidusa Bdv. 7, 10. VIII.
" " alba Stkr. 10. VIII.
" eriphyle Edw. 2, 6-8, 10, 19-21. V-IX.
" autumnalis Ckll. 2, 6-8, 10, 18-20. V-VI.
" alberta Bowman. 12, 15. VI-VII.
" pallidissima Bowman. 12. VI.
45 interior Scud. 1, 6-8, 10, 18-21. VII.
46 christina Edw. 6-8, 18-21. VI-VII.
" pallida Ckll. 8, 20. VII.
47 alexandra Edw. 20. VII.
" alba Stkr. 20, 21. VII.
48 gigantea Stkr. 6-8, 10, 20, 21. VII.
50 pelidne minisni Bean. 19, 20. VII-VIII.
" isni B. & B. 19. VII-VIII.
51 palaeno chippewa Kby. 12. VI.

## PIERIDAE—*Concluded*

52 nastes streckeri Gr. Gr. 19-21. VII-VIII.
" obscurata Verity. 19-21. VII-VIII.
76 Neophasia menapia F. & F. 19. VIII.
80 Pieris sisymbrii Bdv. 12, 18, 19. V-VI.
" flava Edw. 12, 18. V-VI.
81 occidentalis Reark. 6-8, 19-21. VII-IX.
" calyce Edw. 7, 10, 19, 20, 21. IV-V.
" nelsoni Edw. 20. VII.
82 protodice Bdv. & Lec. 2, 6-8, 10. VI-VIII.
" vernalis Edw. 10. IX.
83 napi oleracea Harr. 6-8, 10, 12, 19. V-VI.
" cruciferarum Bdv. 6, 8, 10, 12, 19. VII-VIII.
" marginalis Scud. 18-20. VI-VII.
86 rapae L. 2, 6-8, 10, 18, 19. IV-V.
" yreka Reak. 2, 7, 8, 10, 18. VII-IX.

## DANAIDAE

89 **Danaus** plexippus L. 2, 6-8, 10, 19. VI-VIII.

## SATYRIDAE

109 **Coenonympha** inornata benjamini McD. 2, 6-8, 10, 15, 18, 19. VI-VII.

115 **Eumenis** ridingsii Edw. 2, 5, 6. VII.

117 **Minois** alope nephele Kby. 2, 6-8, 10, 20. VII.
124 oetus Bdv. 1, 2, 5, 6. VII-VIII.

125 **Oeneis** macouni Edw. 6-8, 10, 12, 17, 20. VI-VII.
127 chryxus Dbld. & Hew. 18-21. VI-VIII.
caryi Dyar. 12. VI.
128 daura alberta E. & E. 2, 6, 7, 19. V-VI.
129 taygete Gey. 20. VII.
130 jutta Hbn. 6-8, 10, 19-21. VI-VII.
131 uhleri varuna Edw. 2, 6-8,10, 15, 18-20. V-VII.
135 brucei Edw. 12, 15, 19, 20. VII-VIII.
141 beani E. & E. 19, 21. VIII.

144 **Erebia** disa mancinus Dbld. & Hew. 7, 8, 19-21. V-VII.
148 discoidalis Kby. 6-8, 10, 19-21. IV-V.
150 epipsodea Butl. 1, 2, 6-8, 10, 18. IV-V.

## NYMPHALIDAE (2)

159 **Euptoieta** claudia Cram. 2, 3, 6-8, 10, 18. VI-VII.

165 **Argynnis** cybele leto Behr. 18. VII.
166 " pseudocarpenteri C. & C. 6-8, 10, 18. VI-VIII.
167 aphrodite Fabr. 6-8, 10. VII-VIII.
169 lais Edw. 2, 6-8, 10, 18-20. VI-VIII.
171 atlantis Edw. 6-8, 10, 18-20. VI-VIII.
" beani B. & B. 18, 19. VIII.
178 hydaspe sakuntala Skin. 17-21. VIII.
180 edwardsi Reark. 2, 6, 18. VI.
185 zerene platina Skin. 18. VI.
191 callippe calgariana McD. 2, 3, 6-8, 17, 18, 20. VII-VIII.
" semivirida McD. 18. VII.
199 mormonia eurynome Edw. 2, 6-8, 10, 18-21. VII-VIII.
" clio Edw. 2, 6-8, 18-20. VII-VIII.
" bischoffii Edw. 20, 21. VII-VIII.

200 **Boloria** myrina Cram. 6-8, 10. VII-VIII.
202 aphirape triclaris Hbn. 6-8, 10, 19-21. VI-VII.
" dawsoni B. & McD. 7, 12. VI.
206 chariclea boisduvali Dup. 6, 7, 10, 19-21. VI-VII.
208 freija Thun. 6-8, 10, 19-21. IV-V.

## NYMPHALIDAE (2)—*Concluded*

211 frigga saga Staud. 6-8, 10, 12, 19-21. VI.
212 toddi Holl. 2, 6-8, 10. V-VIII.
213 epithore Edw. 18. VI.
214 alberta Edw. 19. VII.
216 astarte Edw. 19, 20. VII-VIII.

222 **Euphydryas** anicia Dbld. & Hew. 1, 6, 17-21. VI-VIII.
" capella Barnes. 18. VI.
234 colonia beani Skin. 19, 21. VII.
236 gilletti Barnes. 18. VI.

240 **Melitaea** acastus Edw. 5, 6. VI-VII.
244 damoetas Skin. 18, 19. VI-VII.
245 mayi Gund. 19. VII.
246 palla Bdv. 2, 18. VI.
" whitneyi Behr. 17. VI-VII.

262 **Phyciodes** gorgone Hbn. 2, 6-8, 10. V-VII.
265 tharos Dru. 2, 6-8, 10, 19, 20. VI-IX.
266 batesii Reark. 5, 7, 15. V-VI.
267 campestris Behr. 6, 7, 18-21. VI-VIII.

287 **Polygonia** satyrus Edw. 6-8, 10, 18, 19, 21. VII-IX.
288 faunus Edw. 6-8, 10, 12, 18-21. VII-IX.
291 zephyrus Edw. 6, 18-21. VII-IX.
293 oreas silenus Edw. 18, 19. VIII.
294 progne Cram. 2, 6-8, 10, 21. VIII.

295 **Nymphalis** J-album Bdv. & Lec. 6-8, 10, 19-21. VIII.
296 californica Bdv. 6-8, 10, 18, 19, 21. VI-X.
297 milberti Godt. 2, 6-8, 10, 18-21. IV-IX.
" furcillata Say. 8. VI.
298 antiopa L. 2, 6-8, 10, 18-21. VII-IX.

299 **Vanessa** atalanta L. 6-8, 10, 18-21. VI-VIII.
300 virginiensis Dru. 6, 7, 10. VII.
301 cardui L. 6-8, 10, 18-21. VII-IX.
302 carye Hbn. 18, 20. VI-VIII.

321 **Basilarchia** arthemis rubrofasciata B. & McD. 2, 6-8, 10, 18-21. VI-VII.
324 lorquini burrisonii Mayn. 18. VI-VII.
325 archippus Cram. 2, 3, 6, 7. VII.

## LYCAENIDAE

### *Theclinae*

373 **Strymon** melinus Hbn. 6. VI.
380 titus immaculosus Comst. 2, 5-8, 10. VIII.
382 californica Edw. 2. VI-VII.
389 liparops Bdv. & Lec. 7. VII.
" strigosa Harr. 2. VI-VII.

395 **Satyrium** fuliginosa Edw. 18. VI-VII.

403 **Incisalia** augustus Kby. 6, 7, 10, 18-21. V-VI.
409 polios Cook & Wats. 6-8, 10, 12, 18-21. V-VI.
412 eryphon Bdv. 6, 17-21. V-VI.

414 **Callophrys** dumetorum Bdv. 17. V.

### *Lycaeninae*

423 **Lycaena** heteronea Bdv. 18. VII.
424 thoe Guer. 6-8, 10. VII.
427 dione Scud. 2, 3, 6, 7, 10, 18. VII.
428 editha Mead. 6. VI-VII.
429 rubidus Behr. 2, 3. VI-VII.
430 mariposa Reak. 6, 18, 19, 21. VI-VII.
432 helloides Bdv. 2, 6-8, 10, 18, 21. VI-IX.
433 dorcas Kby. 7, 8, 10, 20. VII-VIII.
435 hypophleas arethusa Dod. 6, 17, 19, 21. VI.
437 snowi Edw. 19, 21. VII-VIII.

LYCAENIDAE—*Concluded*

*Plebeiinae*

448 **Everes** amyntula Bdv. 2, 6-8, 10, 18-21. VI.
449 **Plebeius** scudderii Edw. 2, 19-21. VII.
450 melissa Edw. 2, 6-8, 10, 15. V-VIII.
452 aquilo rustica Edw. 6-8, 10, 15. VI-VII.
" megalo McD. 18-21. VI-VII.
453 saepiolus Bdv. 2, 6-8, 10, 19-21. V-VII.
454 optilete yukona Holl. 10, 12. VII.
455 icaroides pembina Edw. 18. VI.
458 shasta Edw. 5, 6. VI.
460 lupini Bdv. 6, 8, 18, 19. VI.
472 **Phaedrotes** piasus Bdv. 6. VI.
473 **Glaucopsyche** lygdamus couperi Grt. 2, 6-8, 10, 19-21. V-VIII.
" columbia Skin. 18. VI.
475 **Lycaenopsis** pseudargiolus lucia Kby. 2, 7, 8, 10, 19. 21. V.
marginata Edw. 2, 7, 8, 10, 19, 21. V.

## Superfamily HESPEROIDEA

### HESPERIIDAE

*Pyrginae*

484 **Epargyreus** tityrus Fabr. 2, 7. VI.
505 **Thorybes** pylades Scud. 6-8, 10, 17. VI.
515 **Pyrgus** centaureae Ramb. 18-21. VII.
516 ruralis Bdv. 18-20. V-VI.
521 communis Grt. 2, 6-8, 10, 21. VI-VII.
" albescens Ploetz. 2. VII.
541 **Erynnis** icelus Scud. & Berg. 2, 6-8, 10, 18-21. V-VI.
546 persius Scud. 2, 6-8, 18-21. V-VII.

*Hesperiinae*

563 **Carterocephalus** palaemon mandan Edw. 18-21. V-VI.
" mesapano Scud. 6-8, 10. V-VI.
569 **Oarisma** garita Reak. 6-8, 10. VII.
579 **Hesperia** uncas Edw. 2, 6, 10. VI-VII.
583 nevada Scud. 6, 7, 18. VI-VIII.
584 comma manitoba Scud. 6, 18-21. VI-VIII.
" assiniboia Lym. 6-8, 18. VI-IX.
611 **Polites** themistocles Latr. 6, 7, 10. VI.
614 peckius Kby. 2, 6-8, 10, 19. VII.
616 draco Edw. 6, 18, 19. VI-VII.
618 mystic Scud. 6-8, 10. VI-VII.
635 **Atrytone** logan lagus Edw. 2. VII.
660 **Amblyscirtes** vialis Edw. 7. VI-VII.

## Superfamily SPHINGOIDEA

### SPHINGIDAE

*Acherontiinae*

707 **Ceratomia** undulosa borealis Clark. 7. VI.
719 **Sphinx** chersis Hbn. 2. VI.
720 vashti Stkr. 2, 6-8, 10. V-VII.
" albescens Tepper. 3, 6-8, 10. V-VII.
721 mordecai McD. 18. VI.
728 gordius campestris McD. 7, 10, 20. VI.
729 luscitiosa Clem. 7, 8, 10. V-VI.
730 druperiferarum marginalis Clark. 8. VI.
733 pinastri L. 8. VII.

SPHINGIDAE—*Concluded*

*Ambulicinae*

739 **Smerinthus** jamaicensis Dru. 10. V-VII.
" geminatus Say. 6-8, 10, 18, 22. V-VII.
740 cerisyi Kby. 3, 6-8, 10, 18-21. V-VII.

741 **Paonias** excaecata borealis Clark. 2, 8, 10. VI.
742 myops occidentalis Clark, 2, 3, 6. VI.
" mccrearyi Clark. 7. VI.

745 **Pachysphinx** modesta Harr. 2, 3, 7, 8, 10, 19. VI.

*Sesiinae*

767 **Hemaris** thysbe cimbiciformis Steph. 2, 7, 8, 10, 19, 21. V-VI.
770 diffinis ariadne B. & McD. 2, 3, 6-8, 10, 19, 21. V-VI.
" rubens Hy-Edw. 6, 8, 18. VI-VII.

*Philampelinae*

785 **Amphion** nessus Cram. 6. VI.

788 **Proserpinus** juanita Stkr. 3, 5. VII.
790 flavofasciata ulalume Stkr. 10, 17, 20. V-VII.

*Choerocampinae*

798 **Celerio** gallii intermedia Kby. 3, 6-8, 9, 10, 18-21. V-VII.
799 lineata Fabr. 2, 3, 6-8, 10, 19-21. VII-IX.

## Superfamily SATURNOIDEA

### SATURNIIDAE

804 **Platysamia** cecropia L. 2, 15. VI.
805 gloveri Stkr. 6, 8, 10, 19. V-VI.
806 columbia nokomis Brodie. 7. V-VI.

812 **Telea** polyphemus Cram. 2, 3, 7, 8, 10. VI.

840 **Pseudohazis** eglanterina Bdv. 18. VI.

## Superfamily NOCTUOIDEA

### AMATIDAE

871 **Cisseps** fulvicollis Hbn. 5-7, 10, 20. VII.

### NOLIDAE

888 **Celama** cilicoides Grt. 3, 6, 7, 10. VII.

### NYCTEOLIDAE

3235 **Nycteola** frigidana Wlk. 7, 8, 10, 13. IX-V. (16)

### ARCTIIDAE

*Lithosiinae*

905 **Lexis** bicolor Grt. 7, 10, 19-21. VII-VIII.

911 **Crambidia** casta Pack. 2, 3, 6, 7, 10, 21. VIII-IX.

952 **Clemensia** albata Pack. 10. VII.

753 **Hypoprepia** miniata Kby. 6-8, 10, 20. VII-VIII.

## ARCTIIDAE—*Concluded*

*Arctiinae*

980 **Halisidota** maculata Harr. 3, 6-8, 10, 18, 20, 21. VI.

1005 **Euchaetias** oregonensis Stretch. 5. VI.

1023 **Eubaphe** ferruginosa immaculata Reak. 6, 7, 10, 19. VI-VII.

1024 **Dodia** albertae Dyar. 7, 17, 21. VI-VII.

1028 **Phragmatobia** fuliginosa rubricosa Harr. 6, 10. V-VI.
1029 assimilans franconia Sloss. 6, 7, 10. IV-VIII.

1031 **Neoarctica** beani Neum. 19, 20. VII-VIII.
1032 sordida McD. 19. VI.

1033 **Apantesis** virgo L. 6, 8, 10, 19, 20. VII.
" simplex Stretch. 10. VII.
" citrinaria N. & D. 8, 10. VII.
1035 parthenice Kby. 3, 6-10, 12. VI-VII.
1036 oithona Stkr. 6.
1037 doris Bdv. 6. VI.
1039 ornata obliterata Stretch. 6. VIII.
1041 quenselii Payk. 6. VII.
1042 turbans Christ. 3, 6-8, 10, 20, 21. VII-VIII.
1044 virguncula Kby. 6, 10, 19, 20. VI-VII.
1047 nevadensis superba Stretch. 6. VII.
N.S. gibsoni McD. 6. VI-VII.
1048 bolanderi Stretch. 6. VI.
1049 blakei Grt. 3, 6. VI-VII.
1051 celia Saund. 19, 20. VI-VII.
1053 williamsii Dodge. 2, 6-8, 10, 18, 20, 21. V-VIII.

1062 **Nemeophila** plantaginis L. 10, 18, 19. VI-VII.
" hospita D. & S. 6, 10, 18, 21. VI-VII.
" scudderi Pack. 7, 10, 18, 20. VII.

1065 **Diacrisia** virginica Fabr. 2, 7, 8, 10. IV-VI.
1066 vagans Bdv. 18. VI.
" kasloa Dyar. 18. VI.
1067 pteridis Hy.-Edw. 10. V-VI.

1069 **Isia** isabella A. & S. 2, 3, 6-8, 10. VI.

1070 **Estigmene** acrea Dru. 2, 3, 6-8, 10. VI.
1072 prima Sloss. 7, 8, 10. V-VII.

1074 **Hyphantria** textor Harr. 3. VIII.

1077 **Turuptiana** permaculata Pack. 2, 3, 5. VII.

1092 **Parasemia** parthenos Harr. 3, 6-8, 10, 18, 19. VI-VII.
1095 yarrowi Stretch. 19, 20. VII-VIII.

1098 **Arctia** caja L. 3, 6, 18-21. VII-VIII.

1103 **Haploa** lecontei militaris Harr. 2. VII.

## AGARISTIDAE

1109 **Androloma** maccullochi Kby. 6, 17-21. VI-VII.

1116 **Alypia** langtoni Couper. 6-8, 10. V-VII.

## PHALAENIDAE

*Pantheinae*

1128 **Panthea** virginaria Grt. 10, 19, 20. VI-VIII.

1141 **Raphia** frater Grt. 7, 10. V.
1143 coloradensis Put. 2, 3. V-VII.

*Acronictinae*

1148 **Acronicta** americana Harr. 7. V.
" eldora Sm. 2. V.
1151 dactylina Grt. 6-8, 10, 20. VI-VII.
1152 hesperida Sm. 10. VII.

## PHALAENIDAE—*Continued*

### *Acronictinae*—Concluded

1153 lepusculina Gn. 2. VII.
" canadensis Sm. 6, 20. VI-VII.
" felina Grt. 6. VI.
1154 leporina cretatoides Benj. 6, 8, 10. V-VI.
1155 innotata Gn. 10, 20. V, VI.
1160 grisea Wlk. 3, 6-8, 10, 19, 20. VI-VII.
1161 tartarea Sm. 6. VI.
1171 quadrata Grt. 6. VI-VII.
1175 furcifera manitoba Sm. 6, 10. V-VII.
1185 fragilis Gn. 7, 10. V-VI.
1201 impleta illita Sm. 5-7, 10. VI-VII.
1202 sperata Grt. 6. VI.
" speratina Sm. 10. VI.
1204 impressa Wlk. 6, 10, 20. VII.
1206 distans Grt. 6-8, 10, 19, 20. IV-V.
1215 oblinita A. & S. 6-8, 10. IV-VI.

1217 **Merolonche** lupini Grt. 19-21. VI-VII.
1221 ursina Sm. 20. VI.

1222 **Simyra** henrici Grt. 3, 6, 7, 10. VI.

### *Phalaeninae*

1224 **Agrotiphila** incognita Sm. 19, 20. VII-VIII.

1232 **Euxoa** olivia Morr. 3. VIII.
1233 brevipennis Sm. 3. IX.
1234 cicatricosa G. & R. 2. VIII.
1236 dargo Stkr. 3, 6, 7. VIII-IX.
1238 quadridentata G. & R. 2, 3, 6, 7, 18. VIII-IX.
1240 laetificans Sm. 2. VIII.
1246 plagigera Morr. 3, 6, 19. VII-IX.
1247 olivalis Grt. 2, 3, 6, 20. VI-VII.
1249 oblongistigma Sm. 3. VII-VIII.
1250 ridingsiana Grt. 2, 3, 6, 7, 10, 18, 19, 21. VII-VIII.
1251 perolivalis Sm. 2, 3, 6, 8, 18. VII-VIII.
1252 flavicollis Sm. 2, 3, 6, 7, 10. VII-VIII.
1254 cooki McD. 6. VIII.
1255 aberrans McD. 3. VII.
1257 catenula Grt. 2, 3. VIII-IX.
1258 lindseyi Blkmre. 6. VIII.
1259 pallipennis Sm. 2, 3, 20. VIII.
1264 mitis colla Stkr. 10. IX.
1271 aurulenta Sm. 6. VII.
1272 detersa Wlk. 3, 10. VIII.
" personata Morr. 10. VIII.
1274 intrita strigilis Grt. 7, 10. VIII.
" reuda Stkr. 6, 10. VIII.
1276 rufula basiflava Sm. 6, 19. VIII.
1277 dodi McD. 3, 6. VIII.
1278 infracta Morr. 3, 18. VIII.
1280 infausta Wlk. 6. VIII.
1282 holoberba Sm. 6, 20. VII.
1297 scandens Riley. 3, 6, 8, 10, 20. VII-VIII.
1298 acornis Sm. 3, 6, 7, 10, 18. VIII-IX.
" testula Sm. 6. VIII-IX.
1301 choris Harv. 3, 6, 10, 21. VII-VIII.
1309 mimallonis Grt. 6, 10, 18. VII-VIII.
1310 messoria Harv. 2, 3, 7, 10, 18. VII.
" atrifera Grt. 3. VIII.
1311 septentrionalis Wlk. 3, 18. VIII-IX.
1312 difformis Sm. 6. VIII.
1314 terrena Sm. 19.
1318 atropulvaria Sm. 18. IX.
1321 fumalis Grt. 20, 21. VII-VIII.
1322 ontario Sm. 10, 19-21. VIII-IX.

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*Phalaeninae*—Continued

1324 quinquelinea lutulenta Sm. 18. IX.
" incallida Sm. 3, 6, 10, 19, 20. VII-IX.
N.S. altera McD. 2, 6. VII-IX.
1326 vallus Sm. 6, 19. VIII-X.
1327 vulpina Sm. 6, 19-21. IX-X.
1329 quebecensis dolens Sm. 6, 18-21. VI-IX.
" quinta Sm. 6, 18. VI-IX.
1339 recticincta Sm. 3, 6. VIII-IX.
1340 murdocki Sm. 19. VIII.
1341 tesselata Harr. 2, 3, 6, 7, 10, 18, 19. VII-VIII.
" atropurpurea Grt. 7, 10, 21. VIII.
" nordica Sm. 6, 10, 21. VII-VIII.
" tesseloides Grt. 3, 6, 10, 21. VII-VIII.
1346 pleuritica Grt. 3, 7. VII.
1347 simona McD. 6. VI-VII.
1349 petruska McD. 6. VI.
1350 pestula Sm. 3, 6, 7, 10, 20. VI-VII.
1351 declarata Wlk. 2, 3, 6, 7, 10, 19-21. VII-IX.
1352 campestris Grt. 3, 7, 10, 19. VII-IX.
1353 verticalis Grt. 10. VIII.
1354 albipennis Grt. 2, 3, 6, 7, 10, 18. VIII-IX.
1356 colata Grt. 6, 20, 21. VII-VIII.
1365 rena Sm. 6-8, 18, 19. VII-VIII.
" cervinea Sm. 6, 8, 18, 19. VIII.
1366 divergens Wlk. 3, 6, 7, 10, 18-20. VI-VII.
" abar Stkr. 20. VII.
1370 obeliscoides Gn. 3, 6, 10. VIII-IX.
" infusa Sm. 3, 6. VIII-IX.
1371 redimicula Morr. 3, 6, 7, 10, 18-20. VI-IX.
" servita Sm. 6. VI-IX.
1372 costata idahoensis Grt. 3, 6, 10, 19-21. VI-VIII.
1373 clausa McD. 3. VII.
1374 westermanni Staud. 20. VII.
1376 basalis Grt. 2, 3, 6-8, 10, 18, 20. VII-VIII.
1378 ochrogaster Gn. 2, 3, 6-8, 10, 15, 19, 21. VI-IX.
" insignata Wlk. 2, 3, 6-8, 10, 19, 21. VI-IX.
" gularis Grt. 2, 3, 6-8, 10, 19, 21. VI-IX.
" turris Grt. 2, 3, 6, 8, 10, 19, 21. VI-IX.
1382 tristicula Morr. 2, 3, 6, 7, 10, 20. VI-VIII.
" nesilens Sm. 2, 3, 7, 10, 18, 20. VI-VIII.
1387 **Chorizagrotis** auxiliaris Grt. 2, 3, 6, 7, 10, 15, 20. VI-IX.
" agrestis Grt. 2, 3, 6, 7, 10, 15, 20. VI-IX.
" montanus Cook. 19, 20. VII.
1389 thanatologia Dyar. 3, 6, 7, 10, 20, 21. VIII.
" sordida Sm. 3, 6, 10, 20, 21. VIII.
" boretha Sm. 6, 10, 20. VIII.
" perfida Dod. 3, 6, 10, 19-21. VIII.
1391 **Protexarnis** balanitis Grt. 3, 6, 10, 18-20. VI-VIII.
1403 **Pseudorthosia** variabilis Grt. 3, 18. VIII-IX.
1404 **Trichosilia** acarnea Sm. 19, 20. VI-VII.
1416 **Agrotis** vetusta Wlk. 3, 6, 10. VI-VIII.
" catenuloides Sm. 3, 7, 10, 21. VIII.
1419 mollis Wlk. 6, 10, 19, 20. VII-IX.
1420 orthogonia Morr. 2-7, 17, 18. VIII-IX.
1421 patula Wlk. 20. VII.
1424 robustior Sm. 3. VI.
1425 venerabilis Wlk. 2, 3, 6, 7, 10, 18. VIII-IX.
1426 vancouverensis Grt. 3, 6, 18-20. VI-VII.
1429 musa Sm. 10. VI.
1432 volubilis Harv. 7, 10, 19, 20. VI-VII.
" stigmosa Morr. 2, 7. VI.
" fumipennis McD. 19, 20. VI.
1433 obliqua Sm. 3, 6, 7, 10. V-VI.
1435 ypsilon Rott. 3, 6-8, 10, 21. VI-X.

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### *Phalaeninae*—Continued

1442 **Feltia** ducens Wlk. 2-10, 19-21. VI-VIII.
1443 hudsoni Sm. 6. VII-VIII.
1446 herilis Grt. 3, 6-8, 10, 19. VII-VIII.

1452 **Actebia** fennica Tausch. 2, 3, 6, 7, 10, 19-21. VI-VIII.

1454 **Copablepharon** grandis Stkr. 3. VII.
1458 viridisparsa Dod. 3, 6. VI-VIII.
1459 longipennis Grt. 3, 7. VIII.
1462 alba Harv. 3. VII-VIII.

1465 **Protogygia** querula Dod. 6. VII.

1472 **Spaelotis** clandestina Harv. 2, 3-8, 10, 15, 18, 21. VI-VIII.
1473 havilae Grt. 3, 6, 10, 18. VI-VII.

1475 **Eurois** occulta L. 3, 6-8, 10, 19, 21. VI-IX.
1476 astricta Morr. 3, 6, 7, 10, 19-21. VI-VIII.
1477 nigra Sm. 3, 6, 19-21. VII-VIII.

1480 **Ochropleura** plecta L. 3, 6-8, 10, 20. V-VII.

1486 **Euagrotis** bairdi Sm. 6.
1490 tepperi Sm. 2, 3, 6, 7, 10, 19, 20. VI-VII.

1494 **Metalepsis** salicarum Wlk. 6-8, 10. IV-V.

1496 **Peridroma** margaritosa Haw. 3, 6-8, 10, 18, 21. VI-X.
" saucia Hbn. 3, 6, 8, 10, 18, 21. VI-X.

1497 **Hemipachnobia** monochromatea Morr. 10. VII.

1498 **Paradisia** littoralis Pack. 2, 3, 6-8, 10, 19, 20. VI-VII.

1499 **Pseudospaelotis** haruspica Grt. 3, 6-8, 10, 19, 20, 21. VI-VII.

1500 **Caradrina** quadrangula clemens Sm. 6. V-VII.

1501 **Chersotis** juncta Grt. 3, 6-8, 20. VII-VIII.

1503 **Diarsia** calgary Sm. 6, 7, 19, 20. VI-VII.
1504 cynica Sm. 6, 7, 10, 21. VII-VIII.
1505 rubifera Grt. 10, 20. VII-VIII.
1506 dislocata Sm. 6, 10, 20. VII.
1510 pseudorosaria Hdwk. 3, 6, 18-20. VI-VII (9).
" freemani Hdwk. 10, 20. VI-VII.

1511 **Graphiphora** c-nigrum L. 2, 3, 6, 7, 10, 19, 21. VII-VIII.
1512 smithi Snell. 3, 6-8, 10, 19-21. VII-VIII.
1513 normaniana Grt. 6, 8, 10, 20. VII-VIII.
1517 oblata Morr. 3, 6, 19-21. VI-VII.
1518 substrigata Sm. 3, 6, 10, 20, 21. VI-VIII.
1521 bollii Grt. 6. IX.
1522 collaris G. & R. 3, 6, 7, 10, 19, 21. VIII.
1525 tenuicula Morr. 3, 6, 7, 10, 19, 20. VII-VIII.
1527 opacifrons Grt. 15, 20. VII-VIII.

1532 **Agrotimorpha** maculata Sm. 19. VII.

1545 **Setagrotis** cinereicollis vocalis Grt. 19. VII.

1550 **Anomogyna** atrata Morr. 8, 10, 20. VII.
1551 sincera H.-S. 20. VI-VII.
1553 apropitia Benj. 6, 19, 20. VII.
1555 perquiritata partita McD. 3, 6, 7, 10, 12, 20, 21. VII-VIII.
1556 laetibilis Zett. 8, 10, 19-21. VII-VIII.
1557 homogena McD. 19-21. VII-IX.
1558 imperita Hbn. 19-21. VII-VIII.
" discitincta Wlk. 21. VIII.
1561 elimata Gn. 19, 21. VII-VIII.
1564 vernilis Grt. 19, 20. VIII-IX.

1568 **Aplectoides** condita Gn. 8, 10. V-VII.

1569 **Anaplectoides** pressus Grt. 6, 7, 10, 20, 21. VII-VIII.
1570 prasina Schiff. 6, 8, 10, 19. VII-VIII.

PHALAENIDAE—*Continued*

*Phalaeninae*—Concluded

1571 **Protolampra** rufipectus Morr. 3, 6-8, 10, 20, 21. VII-VIII.

1574 **Pseudoglaea** olivata Harv. 19. VIII.

1575 **Cryptocala** acadiensis Beth. 3, 6-8, 10, 21. VII-VIII.

1577 **Eueretagrotis** perattenta Grt. 6, 10. VI-VIII.
1579 inattenta Sm. 6, 7, 10, 19. VI-VIII.

1585 **Abagrotis** nanalis Grt. 3. VIII-IX.
1591 dodi McD. 6. VII.
1593 placida Grt. 2, 3, 6, 7, 10, 19, 21. VII-IX.
1594 barnesi nevadensis Benj. 3. VIII.
1601 alternata Grt. 6, 10. VII-VIII.

1611 **Ufeus** satyricus Grt. 2, 6-8, 10, 13, 21. IX-IV.
1614 plicatus Grt. 3, 6, 10, 19, 20. IX.

*Hadeninae*

1625 **Scotogramma** submarina Grt. 5. VII.
1633 trifolii Rott. 2, 3, 7, 10. VIII.
1634 mutata Dod. 3, 6, 10, 18, 19. VI-VIII.
1635 fervida campestris McD. 2. VII.
1640 alta B. & B. 19, 20. V-VII.
1642 obesula Sm. 3, 5, 6, 10, 20. VII-VIII.
1643 farnhami Grt. 3, 6, 7, 10, 19-21. V-VII.
1645 chunka Sm. 2, 3, 6, 7. V.

1652 **Trichoclea** fuscolutea Sm. 3. VI.
1655 artesta Sm. 5, 6. VII.

1660 **Mamestra** configurata Wlk. 2-7, 10. VII-VIII.
1661 curialis Sm. 10. V-VI.

1662 **Polia** discalis Grt. 3, 6, 7, 18, 19, 21. VI-VIII.
1663 nimbosa mystica Sm. 6, 10. VII.
1665 rogenhoferi Moesch. 20. VII.
1666 carbonifera Hamp. 6, 19, 20. VII.
1667 imbrifera Gn. 3, 6-8, 10. VI-VII.
1669 purpurissata Grt. 3, 6, 7, 8, 10, 12, 19-21. VII-VIII.
" juncimacula Sm. 6. VIII.
1673 subjuncta G. & R. 3, 7, 10. VII-VIII.
1677 atlantica Grt. 3, 6, 7, 10. VI-VII.
1678 nevadae Grt. 3, 6, 10, 18, 19. VI-VII.
1679 radix Wlk. 3, 6-8,10, 19, 20, 21. VI-VII.
1680 segregata Sm. 3, 6-8, 10, 19. IV-V.
" negussa Sm. 3, 6, 7, 10, 19, 20. IV-V.
" plicata Sm. 6. IV-V.
1684 tacoma Stkr. 6, 10, 21. VI-VII.
1686 dodi Sm. 3, 6, 7, 10, 18, 20. VI-VII.
1687 lilacina Harv. 3, 6, 7, 10, 19, 20. VI-VIII.
" illabefacta Morr. 3, 6, 7, 10. VII-VIII.
1689 meodana Sm. 3, 6, 18. V-VII.
1691 adjuncta Bdv. 6, 8, 10, 20. VI.
1693 assimilis Morr. 3, 6-8, 10, 19. VI-VII.
1694 pulverulenta Sm. 6, 10, 19, 20. VI.
1696 ingravis Sm. 6-8, 10, 19-21. V-VI.
1697 cristifera Wlk. 10, 19-21. VI.
1698 invalida Sm. 6, 19. V-VII.
1699 lutra Gn. 6, 7, 10, 20, 21. VI-VII.
1707 secedens Wlk. 7, 10, 19, 20. V-VII.
1709 detracta Wlk. 6, 7, 10. VI-VII.
1710 goodelli acutermina Sm. 3, 6, 7, 10. IV-VII.
1711 obscura Sm. 6-8, 10, 21. VI.

1712 **Lacinipolia** meditata columbia Sm. 3, 6-8, 10, 19. VII-VIII.
1714 lustralis Grt. 6, 7, 10, 18. VI-VII.
1716 anguina Grt. 6, 7, 10, 19, 20. VI-VII.
1718 longiclava Sm. 2. V.

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*Hadeninae*—Concluded

1735 vicina Grt. 2, 3, 6, 7, 10, 18-20. V-VII.
1736 pensilis Grt. 6, 18. VIII.
1738 renigera Steph. 3, 6, 7, 10, 19, 21. VII-VIII.
1744 lorea Gn. 1, 3, 6-8, 10. V-VII.
1745 olivacea Morr. 2, 3, 6-8, 10, 19, 21. VII-VIII.
" davena Sm. 10, 18. VII-VIII.

1760 **Lasionycta** alberta B. & B. 6, 17-20. VII.
1765 subfuscula Grt. 18. VI.
1769 conjugata Sm. 18-20. VI-VII.

1775 **Lasiestra** staudingeri Auriv. 19, 20. VI-VIII.
1777 leucocycla poca B. & B. 21. V-VI.
" albertensis McD. 20. VII.
1779 lagganata B. & B. 19. VII-VIII.
1780 impingens Wlk. 19, 20. VII.
1784 luteola Sm. 19, 20. VII-VIII.
1785 promulsa Morr. 16, 18-20. VII.
1787 uniformis Sm. 19, 20. VII.

1789 **Anarta** cordigera Thun. 6, 10, 18-20. V-VI.
1791 melanopa Thun. 19, 20. VI-VIII.
1794 richardsoni Curt. 20. VII.

1800 **Sideridis** rosea Harv. 3, 6-8, 10. V-VII.
1802 maryx Gn. 6-8, 10, 21. VI-VII.

1803 **Astrapetis** sutrina Grt. 6-8, 10, 19, 20. V-VI.

1808 **Anepia** ectrapela Sm. 19. VII-VIII.
1809 circumvadis Sm. 3, 6, 7, 18. VI-VII.

1842 **Orthodes** utahensis Sm. 3. VIII.

1855 **Protorthodes** oviduca Gn. 3, 6-8, 10. V-VI (15).

1886 **Anhimella** contrahens infidelis Dyar. 5-7, 10, 19. VII.

1890 **Homorthodes** furfurata uniformis Sm. 3. VII.

1895 **Nephelodes** emmedonia Cram. 3, 6, 7, 10. VIII.

1899 **Tholera** americana Sm. 3, 6, 18. VIII-IX.

1910 **Xylomyges** cognata Sm. 6.
1914 dolosa Grt. 7, 8, 10, 17, 18. IV-V.
1915 rubrica Harv. 3, 19. V-VI.

1918 **Stretchia** muricina Grt. 2, 18. IV-V.
1920 plusiaeformis Hy.-Ed. 6, 10, 19. IV-V.

1940 **Orthosia** revicta Morr. 6, 10. IV-V.
1943 hibisci Gn. 3, 6-8,10, 20. IV-V.

1950 **Crocigrapha** normani Grt. 3.

1951 **Ceramica** picta Harv. 3, 7, 8, 10, 18. VI-VIII.

1952 **Dargida** procincta Grt. 2, 3, 6-8, 10, 18-20. VI-X.

1962 **Protoleucania** albilinea Hbn. 3, 5-8, 10. VI-VII.

1977 **Leucania** commoides Gn. 2, 3, 6-8, 10, 19. VII-VIII.
1982 multilinea Wlk. 3, 6, 10, 20. VII-VIII.
1986 anteroclara Sm. 2, 3, 6, 19. VI-VIII.
1987 calgariana Sm. 3, 6. VI-VIII.
1992 insueta Gn. 2, 3, 6-8, 10, 19, 21. VII.
" megadia Sm. 6, 8, 10. VII.
1994 unipuncta Haw. 2, 6, 7, 10, 20. VII.
1995 luteopallens minorata Sm. 3, 6-8, 10, 18, 19, 21. VII-VIII.

*Cuculliinae*

2013 **Rancora** solidaginis Stkr. 19. V.
2014 brucei Sm. 20. VI.
2016 albicinerea Sm. 6, 8. IV-V.

PHALAENIDAE—*Continued*

*Cuculliinae*—Continued

2024 **Brachionycha** borealis Sm. 8, 10. IV-V.
2025 **Pleroma** conserta Grt. 18, 19. IV-VI.
2026 obliquata Sm. 6-8, 10, 19. IV-V.
2034 **Cucullia** speyeri Lint. 2, 6, 18. VII-IX.
2038 intermedia Spey. 3, 6, 7, 10, 18. VI-VII.
2039 similaris Sm. 5. VII-VIII.
2041 florea Gn. 2, 6-7, 10, 20. VII-IX.
2042 postera Gn. 3, 6-8, 10, 20. VI-VIII.
2043 omissa Dod. 6, 10, 20. VII-VIII.
2045 montanae Grt. 2, 6. VII.
2049 **Nycterophaeta** luna Morr. 3, 5, 6. VII.
2067 **Oncocnemis** hayesi Grt. 18, 19. IX.
2068 regina Sm. 3. VIII.
2071 albifasciata Hamp. 3, 10. VIII.
2073 pudorata Sm. 19. VII.
2076 lepipoloides McD. 3. VIII.
2077 glennyi Grt. 19. VII.
2087 levis Grt. 3. VIII-IX.
2088 sanina Sm. 3. VIII-IX.
2089 simplex Sm. 3. VIII-IX.
2090 augustus Harv. 2, 3, 10. IX.
2095 occata Grt. 2. V.
2101 viriditincta Sm. 6, 7. VIII.
2114 barnesi Sm. 18, 19. IX-X.
2116 piffardi Wlk. 6, 10, 18, 19, 21. VII-IX.
2117 cibalis Grt. 3, 6, 10, 18. VII-IX.
2122 figurata Harv. 3. VII.
2127 riparia Morr. 3. VIII.
2132 major Grt. 3, 5. VI-VII.
2133 chandleri Grt. 3, 6, 7, 10. VIII-IX.
2136 mackiei B. & B. 3, 6, 7, 10, 19, 21. VII-IX.
2147 **Homohadena** badistriga Grt. 6, 8, 10. VII-VIII.
2150 stabilis Sm. 3, 6, 7, 10, 20. VII-VIII.
2154 fifia Dyar. 3, 6, 7, 10. V-VII.
2155 **Adita** chionanthi A. & S. 3, 7. VIII.
2156 **Apharetra** dentata Grt. 20. VII.
2157 pyralis Grt. 6, 8, 19. VII-VIII.
2161 **Sympistis** zetterstedti Staud. 19, 20. VII.
" labradoris Std. 19, 20. VII-VIII.
2163 funesta cocklei Dyar. 19. VIII.
2183 **Feralia** jocosa Gn. 10. IV.
2186 comstocki Grt. 10. IV-V.
" columbiana Sm. 10. IV.
2201 **Epidemas** melanographa Hamp. 2. IX.
2207 **Bombycia** algens Grt. 6, 7, 10, 19. VIII-IX.
2209 **Brachylomia** discinigra Wlk. 10. VIII.
2210 populi Stkr. 3, 6, 8, 10, 18. VI-IX.
2211 **Hillia** iris Zett. 6-8, 10, 19-21. VIII-IX.
" vigilans Grt. 6, 8, 10, 19-21. VIII-IX.
2212 maida Dyar. 19, 21. IX.
2215 **Litholomia** napaea Morr. 3, 6, 7, 10, 13, 19-21. IX-IV.
2216 **Lithomoia** solidaginis albertae Strand. 6-8, 10, 19, 20. VIII-X.
2221 **Graptolitha** innominata Sm. 8, 10, 12, 17, 18. IX-V.
2223 ferrealis Grt. 10, 12. IV.
2224 amanda Sm. 6, 7, 10, 20, 21. IX-V.
2225 disposita Morr. 3, 10, 13. IX-V.
2241 tepida atincta Sm. 10, 12. IV.
2244 georgii ancilla Sm. 2, 6-8, 10, 16, 18, 21. IX-IV.
2248 fagina Morr. 6, 7, 8, 10, 13. IX-V.
2252 pexata Grt. 6, 8, 10. IX-IV.
2258 thaxteri Grt. 7, 10, 12. VIII-IV.

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*Cuculliinae*—Concluded

2259 **Xylena** nupera Lint. 6-8, 10, 20. V-XI.
2260 curvimacula Morr. 6-8, 10, 12. IX-V.
2262 thoracica Put.-Cram. 3, 6, 8, 10, 12, 16, 19, 20, 21. IX-V.
2263 cineritia Grt. 6, 7, 10, 16, 19-21. IX-V.
2265 **Xylotype** capax G. & R. 8, 10, 20. VII-IX.
2268 **Platypolia** anceps Steph. 6, 8, 10. IX.
2269 contadina albertae McD. 19, 20. IX.
2270 loda Stkr. 18, 19. IX.
2273 **Mniotype** versuta Sm. 3, 6, 7, 10, 18-20. VI-VII (6).
2276 miniota Sm. 6, 10, 20. V-VI.
2278 **Fishia** discors Grt. 2, 3, 10. IX.
2283 enthea Grt. 7, 10, 20, 21. VIII-IX.
2284 instruta Sm. 2, 6, 7, 19. IX-X.
2288 **Anytus** profunda obscura Sm. 6-8, 10. VII-IX.
2298 **Metaxaglaea** signata French. 3. IX-X.
2303 **Eupsilia** tristigmata Grt. 6, 7, 10, 12. IX-V.
2306 devia Grt. 6-8, 10, 16. IX-V.
2309 **Parastichtis** discivaria Wlk. 2, 3, 6, 7, 10, 12, 21. VII-VIII.
" perbellis Grt. 10, 21. VII-VIII.
2312 **Rusina** bicolorago ferrugineoides Gn. 2. X.
2313 verberata Sm. 3, 6-8, 10, 19. IX.
2316 **Xanthia** lutea Strom. 3, 6, 7, 10, 21. VIII-IX.
2318 **Anathix** puta G. & R. 3, 6-8, 10, 21. VIII.
2319 aggressa Sm. 2, 3, 10. VIII-IX.
2321 **Eucirrhoedia** pampina Gn. 3, 6-8, 10, 18. VII-IX.
2322 **Homoglaea** carbonaria Harv. 3, 6, 19, 20, 21. IX-V.
2324 hircina Morr. 6-8, 10. X-V.

*Amphipyrinae*

2342 **Septis** auranticolor barnesi Sm. 3, 6, 19-21. VII-VIII.
" sora Sm. 6, 19. VII-VIII.
2344 vultuosa Grt. 3, 6, 10. VI-VII.
2347 plutonia Grt. 6, 8. VII.
2349 occidens Grt. 6. VI-VII.
2351 arctica Frr. 3, 6, 7, 10, 12, 18-21. VI-VII.
2352 castanea Grt. 19. VII-IX.
2353 alia Gn. 3, 6, 7, 10, 19, 20. VI-VII.
" rorulenta Sm. 6, 10, 19, 20. VI-VII.
2355 inordinata montana Sm. 6, 10, 18. VI.
2357 unita Sm. 6. VI.
2359 cinefacta Grt. 3, 5, 6. VI-VII.
2360 parcata Sm. 3,20. VII.
2361 commoda Wlk. 6, 10. VI-VII.
" alberta Sm. 7, 10, 19, 20. VI-VII.
2362 impulsa Gn. 6, 10, 19, 20. VI-VII.
2364 indocilis Wlk. 6, 10. VII-VIII.
2365 finitima cerivana Sm. 3, 6, 7, 10, 19-21. VI-VII.
2366 **Agroperina** lateritia Hufn. 2, 3, 6-8, 10, 19-21. VI-VII.
2368 dubitans cogitata Sm. 3, 6, 7, 10, 19, 21. VII.
2369 morna Stkr. 6. VI.
2372 indela lineosa Sm. 1, 3, 6, 7, 10, 15. VII-VIII.
" pendina Sm. 2, 3, 6, 10, 15. VII-VIII.
2375 **Crymodes** devastator Brace. 2-8, 10, 15, 19-21. VI-VIII.
2376 maillardi alticola Sm. 19, 20. VII-VIII.
2378 longula Grt. 3. VII.
2381 **Trichoplexia** exornata contradicta Sm. 6, 10. VI-VII.
2383 **Protagrotis** niveivenosa Grt. 3, 6, 7, 10, 19. VII-VIII.
2384 extensa Sm. 3, 5, 10. VII.
2386 nichollae Hamp. 20. VII-VIII.

PHALAENIDAE—*Continued*

*Amphipyrinae*—Continued

2393 **Luperina** passer Gn. 3, 6, 8, 10, 19-21. VI-VIII.
" conspicua Morr. 10, 20. VII.

2411 **Aseptis** characta pluraloides McD. 3. VII.

2417 **Oligia** tonsa subjuncta Sm. 3, 7, 10, 15, 18, 20. VII.
2418 violacea Grt. 19. IX.
2419 egens Wlk. 3, 6, 7, 10, 21. VII-VIII.
2423 illocata Wlk. 8, 10. IX.
2424 mactata Gn. 3, 6-8, 10. IX.
" allecto Sm. 3, 6-8, 10. IX.
2426 fractilinea Grt. 3. VII.

2430 **Eremobina** claudens albertina Hamp. 6, 7, 10, 19. VIII-IX.

2433 **Xylomoia** didonea Sm. 3. VII.

2436 **Spartiniphaga** inops Grt. 2, 6. VIII-IX.
2437 includens Wlk. 7, 10. VII-IX.
2438 panatela Sm. 6, 10. VIII.

2440 **Archanara** subflava Grt. 6, 8, 10, 19. VIII-IX.

2447 **Hypocoena** rufostrigata Pack. 2, 3, 6, 7, 10, 19, 20. VI-VII
2448 inquinata Gn. 3, 10. VII.
2451 basistriga McD. 3, 6, 7, 10, 20. IX.
2452 defecta Grt. 2, 6, 10. VIII-IX.

2453 **Ipimorpha** pleonectusa Grt. 6, 7, 8, 10, 18-21. VII-VIII.
2455 subvexa Grt. 2, 3. VIII.

2457 **Helotropha** reniformis Grt. 6, 7, 10. VIII-IX.
" atra Grt. 6, 7, 10. VIII-IX.

2459 **Apamea** interoceanica Sm. 3, 6-8, 10, 20, 21. VIII-IX.

2467 **Hydroecia** pallescens Sm. 3, 6, 18. VIII-X.
2468 intermedia B. & B. 6. VIII.
2475 perobliqua Hamp. 7, 10. VIII.

2484 **Papaipema** marginidens Gn. 10. IX.
2501 harrisi Grt. 2, 5-6, 10. VIII-IX.
2521 frigida Sm. 10. IX.

2533 **Euplexia** benesimilis McD. 6, 7, 10. VI-VII.

2536 **Phlogophera** periculosa Gn. 10. VII-VIII.
" V-brunneum Grt. 10. VII-VIII.

2547 **Trachea** delicata Grt. 2, 3. VII.

2554 **Chytonix** palliatricula Gn. 10. VI.
" iaspis Gn. 10. VI.

2577 **Leuconycta** lepidula avirida Sm. 5-7. VII.

2582 **Agriopodes** teratophera H.-S. 7, 10. VI.

2586 **Amphipyra** glabella Morr. 3. VII-IX.

2596 **Andropolia** contacta Wlk. 3, 6-8, 10, 16, 19-21. VIII-IX.
2602 aedon Grt. 18. VII.

2607 **Hyppa** xylinoides Gn. 3, 6-8, 10, 19, 20. V-VI.
2608 brunneicrista Sm. 6, 19, 20. VI-VII.
2609 indistincta Sm. 18-20. VII.

2647 **Elaphria** festivoides Gn. 7, 10. VI.

2656 **Platyperigea** extima Wlk. 2, 3, 6-8, 10, 12, 19, 21. VI-VIII.
2657 meralis Morr. 3, 6, 7. VIII.

2661 **Crambodes** talidiformis Gn. 3. VII-IX.

2662 **Proxenus** miranda nitens Dyar. 3, 6, 7, 18, 20, 21. VI-VIII.

2672 **Protoperigia** anotha Dyar. 19. VIII.

2675 **Acopa** perpallida Grt. 3. VI.

2685 **Enargia** decolor Wlk. 3, 6-8, 10, 20, 21. VIII-IX (5).
2685a infumata Grt. 6-8, 10. VIII-IX.

2703 **Arzama** obliqua pallida B. & B. 8, 10. VII-VIII.

2710 **Bellura** diffusa Grt. 10. VI-VII.

PHALAENIDAE—*Continued*

*Amphipyrinae*—Concluded

2715 **Pyrrhia** umbra exprimens Wlk. 6, 8, 10, 19, 20. V-VII.
2734 **Escaria** homogena McD. 3. VI.
2744 **Hadenella** pergentilis Grt. 3. VIII.
2779 **Stibadium** spumosum Grt. 2, 3. VIII.
2791 **Plagiomimicus** expallidus Grt. 2, 3. VIII.
2803 **Stiria** rugifrons Grt. 3. VIII.
2871 **Eutricopis** nexilis Morr. 2, 6, 8, 19, 20. VI-VII.

*Heliothiinae*

2907 **Melicleptria** villosa Grt. 5, 10. VII.
2909 persimilis Grt. 6, 7. VIII.
2916 **Melaporphyria** immortua Grt. 7, 10. V.
2919 **Dysocnemis** borealis Hamp. 6. IV-V.
2920 oregonica Hy.-Edw. 6, 10, 20. V-VII.
2930 **Heliothis** ononis Schiff. 6, 7, 10, 20. V-VII.
2931 phloxiphaga G. & R. 2, 3, 6, 18, 19, 21. V-IX.
2932 armigera Hbn. 6. VIII (10).
2934 **Canthylidia** scutosa Schiff. 3. VII.
2939 **Dasyspoudaea** meadi Grt. 2, 6, 8, 10. VII.
2940 **Rhodophora** gaurae A. & S. 3. VI-VII.
2941 florida Gn. 3, 7, 10. VII.
2956 **Schinia** cumatilis Grt. 3, 6, 7, 20. VII-VIII.
2979 acutilinea Grt. 3, 6. VIII.
3014 jaguarina Gn. 3. VII-VIII.

*Acontiinae*

3117 **Erastria** bellicula Hbn. 8, 10. VI.
3119 albidula Gn. 6, 7, 10. VI.
3124 carneola Gn. 2, 7, 10. VI.
3164 **Conochares** elegantula Harv. 5. VI-VII.
3170 **Tarachidia** tortracina Zell. 3, 6, 10. VI-VIII.
" obsoleta Grt. 5, 10. VI.
3179 binocula Grt. 2. VI.
3185 semiflava Gn. VI.
3191 **Therasea** angustipennis Grt. 2, 3, 6-8, 10, 20. VI-VIII.

*Plusiinae* (19)

3245 **Caloplusia** ignea Grt. 6, 19-21. VI-VII.
3243 **Syngrapha** parilis Hbn. 20. VII.
3244 alticola Wlk. 19, 20. VII-VIII.
3246 microgramma Hbn. 7, 8, 10, 17, 19, 20. VI-VII.
" montana Pack. 7. VII.
3247 orophila Hamp. 19, 20. VII-VIII.
3248 diasema Bdv. 20. VII.
3249 lula Strand. 6, 20. VII.
3250 sackeni Grt. 6. VII.
3254 rectangula nargenta Ottol. 20. VII.
3256 angulidens excelsa Ottol. 19, 20. VII-VIII.
3257 alias Ottol. 20. VII.
" interalia Ottol. 6-8, 10, 19, 20. VII-VIII.
3259 interrogationis L. 19, 20. VII-VIII.
3260 octoscripta Grt. 6, 7, 10, 19-21. VIII.
3263 surena Grt. 20. VII.
3264 epigaea Grt. 6, 7, 10, 19-21. VI-VII.
3266 selecta Wlk. 7, 10, 19-21. VIII.
3252 **Anagrapha** falcifera Kby. 3, 6-8, 10, 19, 20. VI-IX.
" simplex Gn. 2, 3, 6-8, 10, 19, 20. VIII-IX.

PHALAENIDAE—*Continued*

*Plusiinae* (19)—Concluded

3269 **Trichoplusia** ni brassicae Riley. 3, 6, 7, 10, 20. VII-IX.

3273 **Chrysaspidia** putnami Grt. 3, 6-8, 10, 11, 20, 21. VI-VIII.
3304 venusta Wlk. 3, 6, 10, 20. VII-VIII.

3261 **Autographa** v-alba Ottol. 6, 19. VIII.
3265 ampla Wlk. 3, 6, 7, 10, 11, 19, 20. VI-VII.
3271 sansoni Dod. 19, 20. VI.
3272 rubida Ottol. 6, 10, 20. VI-VII.
3285 bimaculata Steph. 3, 6-8, 10, 11, 20, 21. VII-VIII.
3286 mappa G. & R. 6, 7, 10, 20. VI-VII.
3287 pseudogamma Grt. 6, 10, 19-21. V-VII.
3288 californica Spey. 2, 3, 6-8, 10, 18-21. V-IX.
" russea Hy.-Edw. 10. VIII-IX.
3291 flagellum Wlk. 3, 6, 10, 20. VII-VIII.

3295 **Plusia** aereoides Grt. 3, 6-8, 10, 20. VII-VIII.

3298 **Polychrysia** trabea Sm. 6, 10, 20, 21. VII-VIII.

3300 **Eosphoropteryx** thyatyroides Gn. 10. VII-VIII.

3301 **Pseudeva** purpurigera Wlk. 6, 7, 10. VII-VIII.

3305 **Chrysanympha** formosa Grt. 10. VIII.

3307 **Abrostola** urentis Gn. 5, 10. VII.

*Catocalinae*

3344 **Catocala** relicta Wlk. 7, 10. VIII-IX.
" clara Beut. 3, 6-8, 10, 17, 19. VIII-IX.
3346 unijuga Wlk. 2, 3, 6-8, 10, 19, 21. VIII-IX.
" fletcheri Beut. 5. VIII.
3347 parta Gn. 3. VIII.
3349 luciana Stkr. 2, 3. VIII.
3353 hermia verecunda Hlst. 2, 3, 6, 7. VIII-X.
" " diantha Beut. 7. X.
3357 briseis Edw. 2, 3, 6-8, 10, 12, 19-21. VIII-IX.
3361 semirelicta Grt. 8, 10, 21. VIII-IX.

3362 meskei Grt. 2. VIII.
" orion McD. 2, 3. VIII.
" concolorata McD. 3. VIII.
3373 concumbens Wlk. 7. VIII.
3401 blandula manitobensis Cass. 7, 8, 10. VIII.

3426 **Euclidina** cuspidea Hbn. 5-8, 10. V-VI.

3427 **Caenurgina** annexa Hy.-Ed. 5, 6, 18, 20. V-VI.
3429 distincta Neum. 2, 3, 6-8, 10, 18, 19, 21. V-VI.
3430 crassiuscula Haw. 5, 20. VII-VIII.
3431 erechtea Cram. 2, 6, 7, 10, 11. VII-VIII.

3484 **Zale** minerea norda Sm. 2. VI.
3489 duplicata largera Sm. 10. V (17).

3525 **Erebus** odora L. 6, 7, 10, 19. V-VIII.

3556 **Bulia** deducta Morr. 6. VII.

3574 **Synedoida** hudsonica G. & R. 5, 6, 18-21. VI-VIII.
" heathi B. & McD. 5, 7. VII-VIII.
3577 petricola Wlk. 18-21. VI-VII.
" athabasca Neum. 3, 5, 7, 8. VI-VII.
3578 adumbrata saxea Hy.-Edw. 18. VI.
" alleni Grt. 7. VI.
3579 perplexa Hy.-Edw. 5. VII.

3608 **Calpe** canadensis Beth. "Alta". (15).

3615 **Scoliopteryx** libatrix L. 3, 6-8, 10, 19-21. VI-VII.

## PHALAENIDAE—*Concluded*

*Hypeninae*

3684 **Spargaloma** sexpunctata Grt. 10. VI.

3689 **Bomolocha** bijugalis Wlk. 10. VII.
3690 palparia Wlk. 10. VI.
3696 atomaria Sm. 10. VII.
3698 toreuta Grt. 10. VII.
3699 edictalis Wlk. 10. VIII.

3703 **Lomanaltes** eductalis Wlk. 10. VII.

3706 **Hypena** humili Harr. 5, 6, 10, 18, 20. IX-V.
" albopunctata Tepper. 6, 10. IX.
3707 californica Behr. 10. IX-V.

*Rivulinae*

3712 **Mycterophora** inexplicata Wlk. 7, 10. VII.

3728 **Menopsimus** caducus Dyar. 8, 10, 20. VI-VII.

3732 **Rivula** propinqualis Gn. 10. VII.

*Herminiinae* (4)

3733 **Reabotis** immaculalis Hlst. 3. VII.

3734 **Epizeuxis** americalis Gn. 6, 7, 10, 20. VI-VII.
3735 aemula Hbn. 3, 5-7, 10, 20. VII.
3746 lubricalis Geyer. 5. VII.

3750 **Phalaenophana** pyramusalis Wlk. 10. VI.

3765 **Zanclognatha** lutalba Sm. 7, 10. VII.

3767 **Chytolita** petrealis Grt. 1, 3, 7, 8, 10, 21. V-VI.

3770 **Philometra** metonalis Wlk. 6-8, 10, 18. VII-VIII.

3797 **Bleptina** caradrinalis Gn. 3, 10. VI-VII.

3807 **Palthis** angulalis Hbn. 6, 7, 10. VII-VIII.

## PERICOPIDAE

3817 **Gnophaela** latipennis vermiculata G. & R. 6-8, 10, 15, 20. VII-VIII.

## NOTODONTIDAE

3822 **Ichthyura** apicalis Wlk. 3, 6, 7, 10, 18, 21. IV-VII.
3827 albosigma Fitch. 2, 7, 10. VIII.
" specifica Dyar. 3, 6-8, 10, 19-21. IV-V.
3828 brucei Hy.-Edw. 6, 8, 10, 19-21. V-VI.

3843 **Hyperaeschra** stragula Grt. 6-8, 10. VI-VII.

3847 **Odontosia** elegans Stkr. 6, 7, 10, 18, 20. VI-VII.

3850 **Notodonta** simplaria Graef. 6, 7, 10, 20. V-VII.

3851 **Pheosia** rimosa Pack. 7, 8, 10, 18, 19, 21. VII-VIII.

3857 **Nadata** gibbosa A. & S. 7, 8, 10. VI.

3880 **Dasylophia** anguina A. & S. 3. VII.

3919 **Dicentria** semirufescens Wlk. 7, 10. VI-VII.

3924 **Schizura** unicornis A. & S. 3, 6, 7, 10, 17, 20. V-VII.
3927 leptinoides Grt. 10. VII.

3930 **Cerura** multiscripta Riley. 7. VII.
3933 borealis Bdv. 10. VI.
3934 occidentalis Lint. 7, 10. VI-VII.
" gigans McD. 6, 19-21. IV-VI.
3935 cinerea Wlk. 7. V.
" wileyi Dyar. 2, 3. V-VII.
3937 modesta Hud. 6, 7, 10, 19. V-VI.
3938 scolopendrina albicoma Stkr. 3, 5, 6, 10, 18. V-VII.

NOTODONTIDAE—*Concluded*

3939 **Gluphisia** septentrionis Wlk. 2, 5-8, 10, 18, 19. VI-VII.
" ridenda Hy.-Edw. 7, 10. VII-IX.
" albofasciata Hy.-Edw. 10. VII.
" quinquelinea Dyar. 10. V-VII.
3940 lintneri Grt. 6, 7, 10, 19. IV-VII.
" pretians Francl. 7, 10. IV.
3940a severa normalis Dyar. 8, 19-21. V.
" danbyi Neum. 8, 20. V.

LIPARIDAE

3941 **Byrdia** rossi Curt. 8. VI.
3943 **Notolophus** antiqua L. 6, 8, 10, 12, 18, 20. VIII-IX.
3954 **Olene** vagans grisea B. & McD. 5, 6, 7, 10. VI-VII.
" willingi B. & McD. 7, 10. VI-VII.
3958 atomaria Wlk. 2. VII.
" parallela G. & R. 2. VII.
3963 grisefacta Dyar. 10, 19, 20. VII.

## Superfamily BOMBYCOIDEA

LASIOCAMPIDAE

3990 **Malacosoma** lutescens N. & D. 2, 3, 6-8, 20. VII-VIII.
3994 pluviale Dyar. 20. VII.
3997 disstria Hbn. 6-10, 16, 17, 20. VII-VIII.
3999 **Epicnaptera** americana Harr. 2, 6-8, 10, 18-21. IV-V.
" ferruginea Pack. 6, 10, 20. IV.

## Superfamily DREPANOIDEA

THYRATIRIDAE

4004 **Habrosyne** scripta Gosse. 6-8, 10, 16, 19, 20. VI-VII.
4007 **Pseudothyatira** cymatophoroides Gn. 7, 10. VI-VII.
" expultrix Grt. 6, 7, 10, 20. VI-VII
4010 **Euthyatira** pudens Gn. 6, 10. IV-VI.
" pennsylvanica Sm. 10. V-VI.
4014 **Ceranemota** albertae Clk. 3, 6, 8. VIII-IX.

DREPANIDAE

4017 **Eudeilinea** herminiata Gn. 5, 7, 8, 10. VI-VII.
4019 **Oreta** rosea Wlk. 7, 10. VII-IX.
" irrorata Pack. 10. VII-IX.
4020 **Drepana** arcuata siculifer Pack. 7, 10. VI.
4021 bilineata Pack. 10, 18. V-VI.

## Superfamily GEOMETROIDEA

GEOMETRIDAE

*Brephinae*

4023 **Brephos** infans Moesch. 6-8, 10, 18, 19. IV-V.
4025 **Leucobrephos** brephoides Wlk. 6, 8, 10, 21. IV.

*Oenochrominae*

4026 **Alsophila** pometaria Harr. 2, 7. X.

GEOMETRIDAE—*Continued*

*Geometrinae*

4062 **Nemoria** hudsonaria Tayl. 5, 7. VII.
4074 **Synchlora** rubrifrontaria Pack. 3, 6, 7, 10. VI-VII.
4079 **Cheteoscelis** bistriaria Pack. 3, 5. VII.
4090 **Mesothea** viridipennata Hlst. 6-8, 10, 18-21. IV-VI.

*Sterrhinae*

4144 **Scopula** quinquelinearia Pack. 5, 6. VI-VII.
4147 ancellata Hlst. 6, 10, 19, 20. VI-VIII.
4148 junctaria Wlk. 5, 7, 10, 18. VI-VIII.
4149 enucleata Gn. 5. VII.
" adornata Prout. 7. VII.
4150 fuscata Hlst. 1, 18. V.
4151 frigidaria Moesch. 7, 10, 20. VI-VII.
4157 subfuscata Tayl. 18, 19. VI.
4158 inductata delicata Cass. 2, 3, 6, 7, 10, 19, 20. VII-VIII.
4170 **Holarctias** sentinaria Gey. 6-8, 18-20. VI-VII.
4195 **Sterrha** rotundopennata Pack. 5-7, 10, 18. VI-VII.
4204 **Haematopsis** grataria Fabr. 2, 6. VI-VII.
4211 **Cosymbia** pendulinaria griseor McD. 7, 8, 10, 17, 20. VI.

*Larentiinae*

4213 **Carsia** paludata Thun. 10. VII-VIII.
" alpinata Pack. 19. VIII.
4221 **Acasis** viridata Pack. 10. V.
4223 **Nyctobia** limitaria nigroangulata G. & R. 7, 8, 10, 21. IV-V.
4225 **Cladara** atroliturata Wlk. 7, 10. V.
4226 **Lobophora** nivigerata Wlk. 7. V.
4227 montanata Pack. 5-7, 10, 17-21. V-VII.
4235 **Neodezia** albovittata Gn. 6-8, 10, 18, 19. VI-VII.
" tenuifasciata B. & McD. 18. VI-VII.
4239 **Oporophtera** bruceata Hlst. 6-8, 10, 17, 19. IX-X.
4243 **Oporinia** autumnata omissa Harr. 6, 10, 19-21. IX.
" undulata Harr. 20. IX.
4244 **Triphosa** haesitata affirmaria Wlk. 6-8, 10. X-V.
4247 **Calocalpe** undulata L. 3, 6-8, 10, 19-21. VI-VIII.
4248 **Coryphista** meadi Pack. 18. VI-VII.
4267 **Eupithecia** misturata Hlst. 5, 20. VI. (20).
4270 pygmeata obumbrata Tayl. 10. VII.
4271 bryanti Tayl. 5, 18, 20. VII.
4273 regina Tayl. 6, 10. VI-VII.
4274 undata Freyer. 17, 19. VII.
4275 borealis Hlst. 6, 10, 21. VII.
4276 castigata Hbn. 6, 8, 10, 20, 21. VI-VII.
4279 albipunctata Haw. 6, 10, 18, 20. VII.
4281 kasloata Dyar. 10, 20. VI.
4283 luteata Pack. 7, 8, 10, 17-21. VI.
" bifasciata Dyar. 8, 10, 20. VI.
4287 palpata Pack. 10, 17, 19, 21. VI.
4288 columbiata Dyar. 10. IV-V.
4315 monacheata C. & S. 19. VI.
4319 satyrata dodata Tayl. 7, 8, 10, 18, 20, 21. V-VII.
4321 terminata Tayl. 10, 20, 21. VI.
4325 cimicifugata Pears. 10. VI.
4327 ammonata McD. 5-7, 10. VI-VII.
4330 coagulata Gn. 3, 10, 20. VI-VII.
4331 geminata Pack. 6, 10, 20. VII-VIII.
4332 nimbicolor Hlst. 6, 8, 10, 18, 19, 20, 21. V-VI.
4333 gelidata Moesch. 19-21. VI-VII.
4334 multistrigata Hlst. 6, 10. VI-VIII.

GEOMETRIDAE—*Continued*

*Larentiinae*—Continued

4336 perfusca alberta Tayl. 10, 19-21. VI-VII.
4341 georgii McD. 2. VI.
4342 niphadophilata Dyar. 19-21. VIII-IX.
4346 annulata Hlst. 6, 10, 20. IV-V.
4347 usurpata Pears. 20. VI.
4348 filmata Pears. 7, 10, 17-21. IV-V.
4350 cretaceata Pack. 1, 6, 7, 10, 18-20. VI-VII.
4361 stellata Hlst. 10. VI-VIII.
4362 bowmani C. & S. 20, 21. VI-VII.
4366 albicapitata Pack. 8, 10. VI-VII.
4367 columbrata McD. 8, 20. VII.
4383 ravocostaliata Pack. 6-8, 10, 20, 21. IV-VI.
4389 anticaria Wlk. 6-8, 10, 19, 20, 21. V-VII.

4393 **Horisme** intestinata Gn. 6-8, 10, 19, 21. VI, X.
4394 incana Swett. 6, 7, 10, 21. V-VII.

4398 **Eustroma** semiatrata Hlst. 6, 10, 17, 18, 20, 21. VII-VIII. (18).
4400 atrifasciata Hlst. 18, 19. VII-VIII.

4401 **Lygris** diversilineata Hbn. 6, 7. VIII.
4402 propulsata Wlk. 6, 7, 10, 19, 21. VII-VIII.
4403 testata L. 2, 6, 7, 10, 19-21. VII-VIII.
N.S. flavibrunneata McD. 7, 8, 10. VII-VIII.
" unicolorata McD. 7, 10. VII-VIII.
4405 destinata bowmani C. & S. 18-21. VII-VIII.
" lugubrata Moesch. 19-21. VII-VIII.
" similis Wlk. 19-21. VII-VIII.
4406 explanata Wlk. 7, 10. VII-VIII.
" cunigerata Wlk. 7, 10. VII-VIII.
4407 xylina speciosa Hlst. 6, 7, 10, 18, 19, 21. VII-VIII.

4410 **Diactinia** silaceata albolineata Pack. 3, 6, 10, 20, 21. VI-VIII.

4411 **Colostigia** turbata circumvallaria Tayl. 17, 19, 20. VI-VII.

4412 **Plemyria** georgii Hlst. 6, 8, 10, 18, 19, 21. VIII-IX.

4413 **Dysstroma** truncata Hufn. 3, 6, 7, 10, 21. VII-IX.
" walkerata Pears. 10, 19, 20. VII.
4415 mackieata C. & S. 10. VI.
4416 citrata L. 7, 10, 19, 21. VIII.
4419 ethela kasloata Tayl. 6, 7, 10, 20. VII-VIII.
4420 hersiliata cervinifascia Wlk. 10, 20. VII.
" manitoba McD. 6, 7, 10, 20. VII.
" infumata McD. 10. VII.
4424 formosa boreata Tayl. 6, 18. VII-VIII.
N.S. rutlandia McD. 10, 19, 20. VII.

4429 **Ceratodalia** gueneata Pack. 18. VII.

4432 **Thera otisi** Dyar. 3, 18-21. VIII.

4448 **Stamnodes** topazata Stkr. 6, 8, 10, 17, 20. IV-VII.

4465 **Hydriomena** furcata Thun. 6-8, 10, 18-21. VII-VIII.
4477 pluviata Gn. 10. VI.
4478 perfracta Swett. 7, 10, 20, 21. VI-VII.
4485 renunciata Wlk. 10. V-VI.
4489 macdunnoughi Swett. 20, 21. V-VI.
4492 ruberata Frey. 6-8, 10, 20, 21. V-VII.
4496 speciosata morosata B. & McD. 6. VIII.

4509 **Xanthorhoe** lacustrata Gn. 2, 6, 8, 10. V-VII.
4511 designata emendata Pears. 5-7, 10, 18, 20, 21. V-VIII.
4513 munitata convallaria Gn. 3, 7, 10, 18-21. VII-VIII.
4516 ferrugata Clerk. 6-8, 10, 20, 21. V-VII.
4519 incursata lagganata S. & C. 17, 19, 20. VII.
4520 ramaria reclivisata S. & C. 19. VII.
4522 dodata S. & C. 3, 20, 21. VI-VIII.
4526 fossaria atlinensis Swett. 19-21. VI-VIII.
4527 iduata Gn. 10. VI-VII.

## GEOMETRIDAE—*Continued*

### *Larentiinae*—Concluded

4530 abrasaria H.-S. 7, 8, 10, 19, 20. VI-VII.
" congregata Wlk. 7, 10. VII.
" trilineata Warr. 10. VII.

4531 **Zenophleps** lignicolorata Pack. 2, 7, 8, 10, 12, 17, 19, 20. VII-VIII.

4535 **Percnoptilota** obstipata Fabr. 7, 20. IX.
4536 evansi McD. 10. VII.

N.S. **Psycophora** suttoni Hein. 20. VIII.

4540 **Entephria** aurata Pack. 10, 20, 21. VII.
4541 multivagata Hlst. 18-21. VIII.
4543 lagganata Tayl. 19, 20. VIII.

4546 **Mesoleuca** ruficillata Gn. 7, 8, 10, 18, 19, 21. V-VII.
4547 gratulata latialbata B. & McD. 6, 19. V-VI.

4548 **Epirrhoe** tristata L. 6-8, 10, 19-21. V-VI.
4549 plebeculata Gn. 6-8, 10, 12, 18, 19. IV-VI.
4551 alternata Mull. 6, 7, 10, 19, 20. VI-VII.

4555 **Sparganía** magnoliata Gn. 6, 7, 10. VI-VIII.
" pernotata Hlst. 19-21. VI-VIII.
4556 luctuata obductata Moesch. 6, 7, 10, 18, 20. VI-VII.

4558 **Euphyia** unangulata intermediata Gn. 6-8, 10, 21. V-VI.
4561 multiferata Wlk. 6, 7, 10, 17, 19. V-VII.

4573 **Eulype** hastata L. 6-8, 10, 18-21. VI-VII.
" gothicata Gn. 7, 20. VI.
4574 albodecorata confusa McD. 18-20. VI.
" stygiata McD. 7, 20. VI.

4575 **Perizoma** basaliata grandis Hlst. 10. VII-VIII.
4586 custodiata Gn. 5-7. VII.
" polygrammata Hlst. 5. VI-VII.

4587 **Earophila** vasiliata Gn. 6, 10. IV-VII.

4589 **Venusia** cambrica Curt. 10, 20, 21. VII.
4593 pearsalli Dyar. 10, 18, 19, 20, 21. V.

4597 **Hydrelia** albifera Wlk. 10. VI-VII.

4599 **Eudule** mendica Wlk. 10. VI-VII.

### *Ennominae*

4605 **Bapta** semiclarata Wlk. 6, 7, 10. V-VI.

4610 **Deilinia** borealis Hlst. 6, 10, 19-21. VI-VII.
4612 variolaria Gn. 6, 7, 10, 19. VI-VII.
4614 erythemaria Gn. 1, 5-8, 10, 18-21. VI.
4616 bryantaria Tayl. 6, 21. VI.

4622 **Drepanulatrix** falcataria Pack. 18. V.
litaria Hlst. 18. VIII.
4634 unicalcararia Gn. 6. VIII.

4645 **Sericosema** juturnaria Gn. 18. VIII.

4658 **Isturgia** truncataria Wlk. 6, 7, 10, 18-21. V-VII.

4664 **Philobia** ulsterata Pears. 7, 10, 17, 20. VI.
4665 aemulataria Wlk. 7. VIII.

4680 **Semiothisa** granitata Gn. 6-8, 10, 16, 19-21. VI-VII.
4681 oweni Swett. 7, 8, 10. VI.
4682 perplexa McD. 7, 19. VI.
4687 sexmaculata Pack. 7, 8, 10, 12, 16, 20, 21. V-VII.
4688 denticulata Grt. 3, 5-7, 10, 18, 21. V-VIII.
4694 californiaria Pack. 3. VII.
4705 teucaria Stkr. 18, 21. VI-VIII.
4710 continuata Wlk. 5. VI-VII.
4725 neptaria Gn. 2, 3, 18. VI, IX.
4726 mellistrigata Grt. 6, 7, 10. V-VIII.
4727 hebetata Hlst. 2, 6, 7, 10, 18-21. VI-VII.
" ponderosa B. & McD. 2, 6, 7, 10, 18, 20, 21. VI-VII.

GEOMETRIDAE—*Continued*

*Ennominae*—Continued

4730 decorata Grossb. 3, 10. V.
" arubescens McD. 2. VIII.
4735 snoviata Pack. 3. VII.
4737 meadiaria Pack. 2. V.
4746 **Itame** ribearia fascioferaria Hlst. 2, 3. VII.
4747 flavicaria Pack. 1, 6, 10. VII-VIII.
4749 occiduaria Pack. 6-7, 12, 18, 19. VII-VIII.
" andersoni Swett. 20. VII.
4751 sulphurea Pack. 1-3, 5-7, 10. VII-VIII.
4752 fulvaria Vill. 1, 3, 6, 10, 18, 20. VII-VIII.
4753 simplex Dyar. 18-21. VI-VII.
4759 anataria Swett. 12, 16, 18, 20. VII.
4762 exauspicata Wlk. 3, 6, 7, 10. VII.
4771 bitacta Wlk. 3, 6, 7, 12, 18-21. VII.
4772 denticulodes Hlst. 6, 19. VII.
4773 decorata Hlst. 6, 19. VII-VIII.
4774 latiferrugata Wlk. 7. VI.
4782 **Protitame** matilda Dyar. 3, 19. VI.
4784 hulstaria Tayl. 6, 7, 10, 18. V-VI.
4797 **Dysmigia** loricaria Evers. 6, 7, 10, 18-21. VI-VII.
4801 **Hesperumia** sulphuraria Pack. 3, 6, 7, 10, 18, 19, 21. VII-VIII.
4802 **Ematurga** amitaria Gn. 8, 10. V-VII.
4803 **Eufidonia** notataria Wlk. 10, 15, 20. V-VI.
4804 discospilata Wlk. 6-8, 10. VI.
4805 **Orthofidonia** tinctaria Wlk. 6, 10. IV-V.
4806 **Dasyfidonia** avuncularia Gn. 18. V-VI.
4809 **Paraphia** subatomaria Wood. 5. VII.
4811 piniata Pack. 5, 7, 18. VI.
4859 **Melanolophia** imitata Wlk. 18. VI-VII.
4875 **Protoboarmia** porcelaria indicataria Wlk. 7, 10. VI-VII.
4880 **Pseudoboarmia** umbrosaria Hbn. 5. VII.
4902 **Stenoporpia** separataria Grt. 18. VI.
4905 satisfacta B. & McD. 19. VIII.
4908 **Anavitrinella** pampinaria Gn. 7. VII.
4912 **Anacamptodes** larvaria Gn. 7, 10. VI.
4913 emasculata Dyar. 10. VI.
4945 **Aethalura** anticaria fumata B. & McD. 7, 10. V.
4946 **Ectropis** crepuscularia Schiff. 7, 10, 21. IV-VI.
4960 **Paleacrita** vernata Peck. 2. IV.
4963 **Erannis** vancouverensis Hlst. 10. IX.
4966 **Lycia** ursaria Wlk. 7, 8, 10. IV-V.
4967 **Poecilopsis** rachelae Hlst. 2, 6, 7, 8, 10. IV-V.
4968 **Amphidasis** cognataria Gn. 6-8, 10, 19, 21. V-VII.
4992 **Aspilates** orciferaria aberrata Hy.-Edw. 1, 2, 6, 7, 10, 18. VI-VII.
4995 **Euchlaena** obtusaria Hbn. 3, 5, 7. VII.
4997 johnsonaria Fitch. 3, 6, 7, 10. VII.
5000 vinulentaria ochrearia McD. 3, 5-7, 10, 18, 21. V-VII.
5002 marginata albertanensis Swett. 7, 8, 10. V-VI.
5005 tigrinaria sirenaria Stkr. 5-7, 10. VI-VII.
5007 **Xanthotype** sospeta Dru. 3,-6-8, 10. VII-IX.
" manitobensis Swett. 7, 10. VII.
5010 urticaria turbidaria Swett. 7. VI.
5012 **Spodolepis** substriataria danbyi Hlst. 6, 7, 10, 19-21. IV-V.
5015 **Campaea** perlata Gn. 3, 6-8, 10, 12, 18-20. VI-VII.
5034 **Plagodis** approximaria Dyar. 7, 10. V.
5038 alcoolaria Gn. 10. VI.
5042 **Anagoga** occiduaria Wlk. 6-8, 10, 19, 21. V-VI.

## GEOMETRIDAE—*Concluded*

*Ennominae*—Concluded

5043 **Hyperitis** amicaria H.-S. 5, 7, 8, 10, 19. V-VII.
5044 **Nematocampa** limbata Haw. 7, 10. VIII.
5048 **Metarranthis** warneri cappsaria Rupert. 7, 10. V-VI.
5050 duaria septentrionaria B. & McD. 2, 7, 10. V-VI.
5054 **Metanema** inatomaria Gn. 6, 7, 10, 17, 19-21. V-VII.
5055 determinata Wlk. 6, 7, 10, 19, 21. V-VII.
5057 **Selenia** alciphearia Wlk. 6, 7, 10, 19-21. V.
5058 kentaria G. & R. 7, 10. V.
5059 **Ennemos** subsignarius Hbn. 2. V.
5072 **Pero** honestarius Wlk. 3, 6, 7, 10, 18, 19. V-VI.
5075 behrensarius Pack. 19. VI.
5077 occidentalis Hlst. 20, 21. VI.
5080 morrisonarius Hy.-Edw. 6-8, 10, 18. V-VII.
5094 **Enypia** moillieti Blkmre. 18-20. VII-VIII.
5100 **Plataea** trilinearia Pack. 5. VI-VII.
5125 **Caripeta** divisata Wlk. 7, 10. VII.
5128 angustiorata Wlk. 10, 18, 21. VII.
5144 **Besma** endropiaria G. & R. 7. VI.
5145 quercivoraria Gn. 7, 10, 20. VI-VII.
5146 **Lambdina** fiscellaria Gn. 7, 10. IX.
" lugubrosa Hlst. 18. VIII-IX.
5152 **Cingilia** catenaria Dru. 10. IX.
5158 **Neoterpes** trianguliferata Pack. 6, 18-20. V-VII.
5161 **Sicya** macularia Harr. 3, 6-8, 10. VII-IX.
" agyllaria Wlk. 7, 19-21. VIII.
5170 **Deuteronomos** magnarius Gn. 3, 6-8, 10, 19, 21. VIII-IX.
5189 **Synaxis** jubararia Hlst. 6, 8, 10. IX.
5197 **Tetracis** crocallata aspilatata Gn. 7, 10. VI.
5198 cachexiata Gn. 3, 5. VI-VII.
5211 **Prochoerodes** transversata Dru. 2, 3, 7, 8, 10. VII-VIII.

## Superfamily URANIOIDEA

### EPIPLEMIDAE

5223 **Callizzia** amorata Pack. 7, 10. VI-VII.

## Superfamily ZYGAENOIDEA

### LIMACODIDAE

5279 **Tortricidia** testacea Pack. 7. VI.

## Superfamily PYRALIDOIDEA

### PYRALIDAE

*Pyraustinae*

5353 **Desmia** funeralis Hbn. 10. VII-IX.
5367 **Diastictis** argyralis Hbn. 3. VII.
" ventralis Grt. 3. VII.
5427 **Sameodes** elealis Wlk. 8, 10. V-VI.
5436 **Evergestis** subterminalis B. & McD. 18, 20. VII.
5438 simulatalis Grt. 18, 20. VII.
5439 vinctalis B. & McD. 3. V.
5441 obscuralis B. & McD. 18. VI.
5446 straminalis Hbn. 7, 10, 19, 20. VI-VII.
5455 **Nomophila** noctuella Dyar. 7, 10, 20. V-IX.

PYRALIDAE—*Continued*

*Pyraustinae*—Concluded

5462 **Loxostege** chortalis Grt. 7, 10, 18, 20. V-VII.
5478 stictialis L. 2-8, 10, 15, 18. V-VIII.
5479 commixtalis Wlk. 19-21. VI-VII.
5482 indentalis Grt. 3. VI-VII.
5488 albertalis B. & McD. 6, 20. V-VI.
5491 succandidalis Hlst. 3. VII.

5501 **Diasemia** plumbosignalis Fern. 7, 8, 10, 19, 20, 21. VII-VIII.
5506 disputalis B. & McD. 20. VII.

5531 **Titanio** ephippialis Zett. 20. VI-VII.

5545 **Perispasta** caeculalis Zell. 10. VI-VII.

5546 **Phlyctaenia** rubigalis Gn. 10, 20. VI-VII.
5550 nordeggensis McD. 20. VI.
5553 itysalis Wlk. 7, 8, 10, 18, 20, 21. VI-VII.
5558 radiosalis Moesch. 8, 19, 20. VII-VIII.
5559 indistinctalis Warr. 20. VII.
5561 terrealis Tr. 10. V-VII.
5562 extricalis Gn. 20. VII.
5564 tertialis Gn. 10, 20. V-VII.

5576 **Pyrausta** pertextalis Led. 10. VI.
5586 submedialis Grt. 3. VII.
5598 fumalis Gn. 10. VII-VIII.
5602 fumoferalis Hlst. 7, 10. V-VII.
5605 mustelinalis Pack. 7, 10, 18, 20. VI-VII.
5607 unifascialis Pack. 7, 10, 18, 20, 21. VI-VIII.
5609 fodinalis Led. 6, 10, 18. VI-VII.
5621 borealis Pack. 8, 10, 19, 20. V-VII.
5622 subsequalis plagialis Haim. 3. VII.
5624 generosa G. & R. 8, 10. V-VII.
5625 ochosalis Dyar. 7, 8, 10, 20. VI-VII.
5633 signatalis Wlk. 1, 6, 18. VI-VII.
5638 nicalis Grt. 10, 20. VI-VIII.
5645 marginalis Wlk. 8, 10, 20. V.
5647 funebris Strom. 6-8, 10, 18, 20. VI-VII.

5655 **Cornifrons** simalis Grt. 3, 6. VII.

5659 **Noctuelia** rufofascialis Steph. 6, 10, 18. VI-VII.

*Nymphulinae*

5686 **Nymphula** obliteralis Wlk. 10. VI.

*Scopariinae*

5725 **Scoparia** centuriella D. & S. 6-8, 10, 18, 20, 21. VI-VII.
5742 lugubralis Wlk. 10, 20. VI-VIII.
5745 albertalis Dyar. 19. VII.
5746 phycitinalis Dyar. 19. VI-VII.
5747 basalis Wlk. 8, 10, 20. VI-VII.

*Pyralinae*

5758 **Pyralis** farinalis L. 3, 6-8, 10, 20. VII-VIII.

5770 **Herculia** thymetusalis Wlk. 10. VII.

*Chrysauginae*

5805 **Acallis** gripalis Hlst. 3. VI, VII.

*Schoenobiinae*

5827 **Schoenobius** mellinellus Clem. 10. VI-VIII.
5830 forficellus Thun. 10. VII.

## PYRALIDAE—*Continued*

### *Crambinae*

5848 **Pseudoschoenobius** opalescalis Hlst. 1. VII.
5850 **Raphiptera** argillaceella Pack. 17, 20. VI-VII.
5857 **Crambus** pascuellus L. 10. VII.
5860 girardellus Clem. 8, 10. VI-VII.
5861 leachellus Zinck. 2, 7, 10. VIII-IX.
N.S. ainslieellus Klots. 3. VIII. (12, 13).
5862 unistriatellus Pack. 10, 20. VI-VII.
5863 praefectellus Zinck. 7. IX.
5864 carpenterellus Pack. 19. VIII.
5867 bidens Zell. 10. VIII.
5868 labradoriensis Christ. 20. VI-VII.
5871 whitmerellus browni Klots. 1, 10, 19, 20. VII-VIII.
5872 trichusalis Hlst. 18, 20, 21. VIII.
5873 cockleellus Kft. 19. VIII.
5877 awemellus McD. 10. VIII.
5878 myellus Hbn. 8, 20. VII.
5883 hortuellus topiarius Zell. 10, 20. VI-VII.
5887 innotatellus Wlk. 2, 10, 20. VII-VIII.
5892 vulvivagellus Clem. 3, 7, 10. VIII.
5893 plumbifimbriellus Dyar. 18. VI.
5894 dorsipunctellus Kft. 7, 8, 10. VII-VIII.
5895 ruricolellus Zell. 8, 10, 20. VII-VIII.
5904 truncatellus Zett. 8, 10, 20. VI.
5906 paganellus McD. 20. VII.
5907 oregonicus Grt. 19. VII-VIII.
5915 nevadellus Kft. 18, 20. VI-VII.
5919 trisectus Wlk. 2, 6, 7, 10. VII-IX.
5921 laciniellus McD. 3, 6, 8, 10, 20. VII-VIII.
5922 edmontellus McD. 3, 6, 8, 10, 20. VII-VIII.
5925 caliginosellus Clem. 10. VII.
5927 zeellus Fern. 18. VI.
5928 luteolellus Clem. 10. VII.
5934 **Thaumatopsis** pexellus coloradellus Kft. 3, 10, 18. VIII.
5937 fernandellus nortellus Kft. 6. VII.
5952 **Ommatopteryx** texana Rob. 10. VIII.
5979 **Occidentalia** comptulatalis Hlst. 10. VII.

### *Epipaschiinae*

6021 **Jocara** breviornatalis Grt. 3. VII.
6022 trabalis Grt. 3. VII.
6042 **Tetralopha** aplastella Hlst. 10. VI-VII.

### *Phycitinae*

6062 **Myelois** subtetricella Rag. 10, 20. VI-VIII.
6063 obnupsella Hlst. 5, 7, 10. V-VI.
6067 bistriatella Hlst. 10. VI-VIII.
6071 coniella Rag. 2, 10. VIII.

6111 **Mineola** tricolorella Grt. 10. VI-VIII.

6129 **Dioryctria** abietella D. & S. 19. VII.
6130 ponderosae Dyar. 20. VIII.
6131 reniculella Grt. 10, 20. VII-IX.
6132 actualis Hlst. 7, 10, 18, 20. VI-VII.

6150 **Polopeustis** annulatella arctiella Gib. 20. VII.

6156 **Ambesa** laetella Grt. 2, 3, 6, 7, 10, 18. VI-VII.
6157 niviella Hlst. 20. VII.
6159 columbiella McD. 3. VII.

6163 **Nephopteryx** ovalis Pack. 10, 18, 20. VI-VII.
6167 fasciolalis Hlst. 18, 19. VII-VIII.

6178 **Tlascala** umbripennis Hlst. 18. VI.

6184 **Meroptera** pravella Grt. 10. V-VI.

## PYRALIDAE—*Concluded*

### *Phycitinae*—Concluded

6189 **Immyrla** pasadamia Dyar. 10. VII.
6209 **Salebria** basilaris Zell. 10. V-VII.
6223 **Myrlaea** tarmitalis Hlst. 10, 21. V-VIII.
6226 fernaldi Rag. 10. V-VII.
6227 **Laodamia** fusca Haw. 10, 20. VI-IX.
6235 **Pyla** scintillans Grt. 18. VI.
6237 aeneoviridella Rag. 2. VIII.
6240 incorruscella Hlst. 1, 18, 19. VI-VII.
6241 criddlella Dyar. 18, 20. V-VI.
6243 rainierella Dyar. 19. VII.
6251 **Epischnia** boisduvaliella Gn. 3, 8, 10. VII.
6253 fulvirugella Rag. 19, 20. VI-VII.
6254 albocostialis Hlst. 3. VI-VII.
6256 vividella McD. 3, 6, 8, 10. VI.
6261 **Megasis** caudellella Dyar. 7, 10. V.
6265 indianella Dyar. 5, 6. IV-V.
6278 **Melitara** dentata Grt. 2, 3, 6. VIII.
6282 **Olycella** nephelepasa Dyar. 2. V.
6303 **Zophodia** convolutella Hbn. 10. IV-V.
6318 **Euzophera** ochrifrontella Zell. 10. VI-VII.
6337 **Staudingeria** albipenella olivacella Dyar. 3, 8, 20. VI-VII.
6341 **Hulstia** undulatella Clem. 2, 3, 6, 8, 10, 20. VII-VIII.
6363 **Homoesoma** impressale Hlst. 3, 6. VII.
6364 uncanale Hlst. 10. VI-VII.
6366 illuviellum Rag. 6, 18. VI.
6370 mucidellum Rag. 3, 18, 20. VII-VIII.
6371 stypticellum Grt. 10. VI.
6372 reliquellum Dyar. 8, 10. VI-X.
6374 electellum texanellum Rag. 3, 18. VI-VII.
6379 **Ephestiodes** gilvescentella Rag. 3. VII.
6396 **Moodna** pelviculella Hlst. 10. VII.
6397 nigrella Hlst. 10. VII.
6399 **Ephestia** kuehniella Zell. 2, 3, 6, 10. I-XII.
6401 elutella Hbn. 10. VI-IX.
6408 **Plodia** interpunctella Hbn. 10. X-VI.

### *Anerastiinae*

6439 **Peoria** approximella Wlk. 3, 6. VI-VII.
6444 **Anerastia** lobella Hbn. 10. VI-VII.
6456 **Coenochroa** inspergella Rag. 2. VI.

## PTEROPHORIDAE

6463 **Trichoptilus** lobidactylus Fitch. 10. VII.
6467 **Pterophorus** tenuidactylus Fitch. 3, 18. VI.
6469 raptor Meyr. 3, 18. VI.
6470 ningoris Wlshm. 10. VI-VII.
6471 delawaricus Zell. 18. VI.
6474 **Platyptilia** tessaradactyla L. 18-20. VI.
6476 pallidactyla Haw. 7, 10, 18, 20. VI-VII.
6477 carduidactyla Riley. 3, 7, 8, 10, 18. V-VII.
6478 percnodactyla Wlshm. 18, 20. VII.
6479 williamsi Grin. 20. VI-VII.
N.S. comstocki Lange. 2. VI-VII.
6481 albicans Fish. 18. VI.
6482 albertae B. & L. 19. VIII.
6484 punctidactyla Haw. 3, 10, 18-21. V-IX.
6490 edwardsii Fish. 3, 18, 19. VI-VII.
6491 albiciliata canadensis McD. 18-20. VI-VII.

PTEROPHORIDAE—*Concluded*

6492 nana McD. 18, 19. VI.
6493 shastae Wlshm. 18. VI.
6497 albidorsella Wlshm. 18. VI.
6498 maea B. & L. 18-20. VIII.

6511 **Stenoptila** bowmani McD. 6, 20. V-VIII.
6513 coloradensis Fern. 3, 8, 10, 19-21. VII-IX.
6514 columbia McD. 18-20. VI-VII.

6519 **Adaina** montana declivis Meyr. 8, 10. VIII.
6520 cinerascens Wlshm. 18. VI.

6523 **Oidaematophorus** occidentalis Wlshm. 18. VIII.
6527 mathewianus Zell. 19, 20. VII-VIII.
6531 phaceliae McD. 3, 8, 10. VII.
6532 grisescens Wlshm. 3. VII.
6534 rileyi Fern. 18, 19. VI.
6535 lindseyi McD. 8, 10. VII-VIII.
6541 gratiosus Fish. 19. VII.
6545 brucei Fern. 6, 7, 10, 20. VI-VII.
6560 helianthi Wlshm. 19. VII.
6561 homodactylus Wlk. 10, 18-21. VI-VII.
6562 elliottii Fern. 10, 20. VI-VII.
6563 stramineus Wlshm. 3, 8, 18-20. VI-VIII.
6568 lacteodactylus kellicottii Fish. 10. VI.
6578 corvus B. & L. 18, 20. VI.
6588 monodactylus L. 10, 20. VI-X.
N.S. balsamorrhizae McD. 18. VI-VII.

ALUCITIDAE

6591 **Alucita** huebneri Wallen. 3, 7, 8, 10, 20, 21. X-IV.

## Superfamily TORTRICOIDEA

OLETHREUTIDAE

*Olethreutinae*

6596 **Bactra** furfurana Haw. 10. VII-VIII.
6597 verutana Zell. 3, 10. VIII.

6620 **Endothenia** montanana Kft. 10. V-VI.
6621 heinrichi McD. 10. VI.
6625 hebesana Wlk. 8, 10, 18, 20. VI-IX.
6628 infuscata Hein. 10. VI.
6629 antiquana nubilana Clem. 3, 6, 8, 10, 20. VI-VII.

6630 **Taniva** albolineana Kft. 8, 10, 20. VI-VII.

6631 **Tia** vulgana McD. 20. VI.

6633 **Esia** approximana Hein. 10. VII-VIII.

6638 **Aphania** capreana Hbn. 8, 10, 19, 20. VI-VII.
6639 youngana McD. 10. VI-VII.
6640 frigidana Pack. 10, 20. V-VII.
6643 tertiana McD. 10. VI.
6648 apateticana McD. 8, 10. V-VII.
6650 dextrana McD. 6, 10, 19, 20. VII.
6651 infida Hein. 6, 8, 10, 18, 20. VI-VII.
6652 removana Kft. 8, 10, 20. VII-VIII.

6653 **Sciaphila** duplex Wlshm. 7, 10, 18. VI-VII.
" thalassana McD. 10. VI.

6654 **Badebecia** urticana Hbn. 3, 8, 10, 18, 20. VI-VIII.

6666 **Exartema** rusticanum McD. 10. VIII.
6670 punctanum Wlshm. 10. VII.
6672 inornatanum Clem. 10, 20. VI-VII.
6694 versilicoloranum Clem. 10. VII.
6700 appendicium Zell. 8, 10. VI-VII.

OLETHREUTIDAE—*Continued*

*Olethreutinae*—Concluded

6706 **Hedia** separatana Kft. 8, 10, 20. V-VI.
6707 ochroleucana Hbn. 3, 7, 8, 10, 18, 21. VI-VII.
6717 **Olethreutes** siderana chalybeana Wlshm. 18. VI.
6718 sordidana McD. 20. VII.
6719 galaxana Kft. 2, 18-20. VI.
6721 astrologana Zell. 6, 8, 10. VI-VII.
6723 puncticostana Wlk. 8, 10, 20. VI-VII.
" major Wlshm. 8, 10, 20. VI-VII.
6724 nordeggana McD. 20. VII.
N.S. kennethana McD. 10. VII-VIII.
6727 deprecatoria Hein. 10. VII.
6728 cespitana Hbn. 8, 10, 18-20. VI-VIII.
6729 carolana McD. 10, 18. VII.
6730 polluxana McD. 19, 20. VII.
6731 glaciana Moesch. 6, 10, 18, 20. VI-VIII.
6732 bipartitana Clem. 6, 10, 18, 20. VI-VIII.
6734 schulziana Fabr. 10, 20, 21. VI.
6735 intermistana Clem. 10, 19, 20. VII.
6738 bowmanana McD. 19, 20. VII.
6740 costimaculana Fern. 6. VII.
6742 buckellana McD. 20. VI.
6743 **Evora** hemidesma Zell. 10. VII.

*Eucosminae*

6756 **Petrova** albicapitana Busck. 10. VI.
6763 pallipennis McD. 20. VI.
6764 burkeana Kft. 10, 20. VII-VIII.
6766 **Barbara** colfaxiana taxifoliella Busck. 18. VI.
6771 **Thiodia** albertana McD. 19. VI.
6773 awemeana Kft. 8, 10. V-VI.
6774 indeterminana McD. 8, 10, 18. V-VI.
6778 formosana Clem. 6, 10. V-VI.
" subcandida Hein. 10. VI.
6780 corculana Zell. 18. V.
6782 refusana Wlk. 8, 10. V.
6783 amphorana Wlshm. 6. VII.
6787 ochroterminana Kft. 10. VI-VIII.
6790 alterana Hein. 10. VI-VIII.
6791 marmontana Kft. 8, 10, 18, 20. VI-VIII.
6792 sinestrigana McD. 10. VII.
6793 oregonensis Hein. 18. VI.
6797 convergana McD. 6. V.
6804 influana Hein. 3. VII.
6809 elongana Wlshm. 20. VI.
6810 rupestrana McD. 6, 18-20. V-VII.
6812 tarandana Moesch. 3, 6, 8, 10, 18-20. V-VI.
6813 nepotinana Hein. 5. VI.
6815 spectana McD. 10. VIII-IX.
6820 parvana Wlshm. 3. VI.
6821 fertoriana Hein. 10, 18. VI.
6825 indagatricana Hein. 10, 18. VI-VIII.
6828 dorsiatomana Kft. 3, 10, 18. VI-VII.
6829 striatana Clem. 10, 19, 20. VII.
6833 modicellana Hein. 3, 10, 18. VII.
6836 pallidicostana Wlshm. 3, 8, 10. VII.
6840 artemisiana Wlshm. 10. VIII.
6841 infimbriana candidula Hein. 10, 20. VII.
6842 octopunctana Wlshm. 10. VII.
6843 youngi McD. 18. VII.
6861 offectalis Hlst. 10. V-VII.
6870 **Eucosma** ridingsana Rob. 6-8, 10, 19. VII-VIII.
6885 argentiana Wlshm. 3, 5. VI.
6888 serpentana Wlshm. 3, 10. VII.

## OLETHREUTIDAE—*Continued*

*Eucosminae*—Continued

6889 ophionana McD. 3, 18, 20. VI-VII.
6891 argentialbana Wlshm. 2, 3, 5, 6, 8, 10, 18, 20. V-VII.
6892 morrisoni Wlshm. 3, 6, 8, 10, 18, 20. VI-VII.
6894 pergandeana Fern. 3, 6, 10, 18, 20. VI-VII.
6898 vagana McD. 8, 10. VII.
6901 galenapunctana Kft. 3. VII.
6904 serapicana Hein. 3, 18. VI.
6905 watertonana McD. 18. VII.
6909 scintillana Clem. 10. VII.
" randana Kft. 3, 10. V-VI.
6915 luridana Wlshm. 5. VI.
6918 subflavana Wlshm. 3. VII.
6933 lolana Kft. 18, 19. VIII.
N.S. louisana McD. 19. VII-VIII.
6934 dodana Kft. 19. VII.
6936 invicta Wlshm. 3. VIII.
6949 occipitana Zell. 3, 18, 20. VII.
6959 bilineana Kft. 2, 3, 10. VI.
6961 fuscosparsa Wlshm. 10. VI.
6962 mediostriata Wlshm. 3. VI.
6969 nandana Kft. 10. VIII.
6970 landana Kft. 6, 7. V.
6971 simplex McD. 6. IV.
6972 dorsisignatana Clem. 7, 10. VIII-IX.
" diffusana Kft. 10. IX.
6974 juncticiliana Wlshm. 8, 10. VI-VIII.
6975 derelicta Hein. 18. VII.
6976 excusabilis Hein. 18. VII.
6985 corosana Hein. 6. VII.
6988 pulveratana Wlshm. 6. VII.
6991 hohana Kft. 19. VIII.
6995 suadana Hein. 3. VI.
7004 cataclystiana Wlk. 3, 10, 18. VI-VII.

7034 **Epiblema** purpurissatana Hein. 10. VI-VII.
7035 walsinghami Kft. 10. V.
7036 periculosana Hein. 18-20. VI-VII.
7042 illotana Wlshm. 3, 10, 18. VI.
7043 culminana Wlshm. 8, 10, 18. VII-VIII.
7047 abbreviatana Wlshm. 10. V.

7058 **Gypsonoma** fasciolana Clem. 6, 8, 10, 20. V-VII.
7059 nebulosana Pack. 10. VII.
7060 parryana Curt. 10. VI.
7062 substitutionis Hein. 10. VI-VIII.
7063 salicicolana Clem. 10. VIII.
7064 adjuncta Hein. 10. VI-VII.

7065 **Proteoteras** aesculana Riley. 10. IV.
7067 willingana Kft. 3-8, 10. VI.
7068 crescentana Kft. 2, 10. VII.

7075 **Zeiraphera** dineana Gn. 16, 20. VII.
7077 fortunana Kft. 10. VIII.

7078 **Pseudexentera** oregonana Wlshm. 6-8, 10. IV-V.
7081 perstructana Wlk. 10, 20. VIII-IX.

7097 **Griselda** radicana Wlshm. 10, 18, 20, 21. VII-IX.

7106 **Epinotia** similana Hbn. 18, 20. VII.
7107 sperana McD. 10, 20, 21. VIII-IX.
7109 solandriana L. 18, 20, 21. VII-VIII.
7114 castaneana Wlshm. 19. VII.
7116 madderana Kft. 10. VII.
7128 rectiplicana Wlshm. 8, 10. VI.

## OLETHREUTIDAE—*Concluded*

### *Eucosminae*—Concluded

7129 corylana McD. 10. VI-VII.
7130 solicitana Wlk. 10, 20. V-VII.
7132 nisella Clerck. 7-9, 19, 20. VII-IX.
7135 transmissana Wlk. 8, 10. VI-VII.
7136 removana McD. 18. VI.
7137 momonana Kft. 10. VII-VIII.
7140 silvertoniensis Hein. 3, 18, 20. IX.
7142 digitana Hein. 19. VII.
7143 nigralbanoidana McD. 3, 18. VI.
7149 crenana Hbn. 8, 10, 19, 20. IV-V
7153 arctostaphylana Kft. 20. IX.
7159 nonana Kft. 3. VII.
7163 lomonana Kft. 10. IX.
7165 medioplagata Wlshm. 3, 10, 18, 20. VII-VIII.
7167 cruciana L. 10, 18, 19, 20. VII-IX.
7170 seorsa Hein. 18. IV.
7172 lindana Fern. 10. VIII-IX.

7175 **Anchylopera** nubeculana Clem. 8, 10, 18. V-VI.
7176 subaequana kincaidiana Fern. 10, 18, 20. V-VI.
7178 discigerana Wlk. 10. VI.
7179 tenebrica Hein. 10. VI.
7181 angulifasciana Zell. 8, 10, 20. VI-VII.
7184 burgessiana Zell. 10. VI-VII.
7185 mira Hein. 8, 10. VI.

7193 **Ancylis** comptana Froh. 3, 10, 18, 20. V-VI.
" cometana Wlshm. 20. V.
7195 apicana Wlk. 10. V-VI.
7197 carbonana Hein. 20. V-VI.
7198 diminutana Haw. 10, 20. V-VII.
7199 goodelliana Fern. 10, 18, 20. V-VI.
7201 unguicella L. 10, 18, 20. V.
7203 mediofasciana Clem. 7, 8, 10, 18, 20. V-VI.
7205 tineana Hbn. 10, 20. V-VII.

7209 **Hystricophora** stygiana Dyar. 1, 3, 6, 7, 18. VI-VII.
7212 asphodelana Kft. 3, 8, 18. VI.
7214 ochreicostana Wlshm. 3. VII.

### *Laspeyresiinae*

7219 **Dichrorampha** kana Busck. 18, 19. VI.
7221 britana Busck. 18. VI.
7228 piperana Busck. 20. VI.
7229 sedatana Busck. 18. VI.

7236 **Hemimene** felicitana Hein. 10. VI.
7237 signifera Hein. 10. VI.
7239 bowmanana McD. 10, 20. V.

7244 **Grapholitha** packardi Zell. 10. VI-VII.
7245 prunivora Wlshm. 10, 18. VIII.
7251 imitativa Hein. 18. V.
7252 lunatana Wlshm. 7, 10, 20. V.
7254 interstinctana Clem. 18, 20, 21. VI-VII.

7263 **Laspeyresia** rana Forbes. 20. VII.
7271 multilineana Kft. 10. V-VI.
7272 ingrata Hein. 10. V.
7275 populana Busck. 3, 10, 20. V-VII.
7276 youngana Kft. 7, 10, 15. V-VI.
7277 nigricana Steph. 5, 10, 20. VI-VII.
7284 prosperana Kft. 18, 19. VI.
7288 lautiuscula Hein. 10. V.
7289 flexiloqua Hein. 6, 10, 20. VII.

## TORTRICIDAE

7314 **Amorbia** humerosana Clem. 10. V.

7323 **Sparganothis** reticulatana Clem. 3, 10. VII.
7333 irrorea Rob. 10. VI-VII.
7334 xanthoides Wlk. 8, 10. VII.
7336 violaceana Rob. 8, 18. VI.
7338 vocaridorsana Kft. 3, 8, 18. VI-VII.
7349 sulfureana Clem. 8. VII.

7369 **Platynota** idaeusalis Wlk. 10. VI-VII.

7370 **Pandemis** canadana Kft. 10, 12. VI-VIII.

7378 **Archips** persicana Fitch. 10, 18-20. VI-VII.
7384 cerasivorana Fitch. 10, 18. VII-VIII.
7388 argyrospila Wlk. 10. VII.
7390 eleagnana McD. 20. VII.
7397 melaleucana Wlk. 10. VII.
7403 symphoricarpana Kft. 2. VII.
7404 arcticana Moesch. 10, 20. V-VI.
7405 rosaceana Harris. 3, 7, 10, 12, 13, 15, 18. VI-VIII.
7406 striana Fern. 10. VI-VII.
7407 conflictana Wlk. 1, 6, 10, 18-20. VI-VII.

7408 **Choristoneura** fumiferana Clem. 10, 19-21. VII-VIII. (7).

7410 **Tortrix** pallorana Rob. 3. VII.
7411 clemensiana Fern. 10. VII-VIII.
7415 alleniana Fern. 3, 6, 10. VI-VII.
7418 packardiana Fern. 10, 19, 20. VII.
7420 peritana Clem. 10. VI-VIII.
7423 virescana Clem. 8, 10, 20. VII.
7428 wellingtoniana Kft. 10, 20. V-VI.
7437 moeschleriana Kft. 18. VIII.
7439 afflictana Wlk. 10. V-VII.
7440 alberta McD. 10, 20. VII-VIII.

7442 **Eulia** ministrana L. 10. VI.

7443 **Argyrotaenia** velutinana Wlk. 8, 10, 21. V.
7445 pinatubana Kft. 20. V.
N.S. occultana Freeman. 20. VI.

7455 **Tortricodes** horariana Wlshm. 8, 10, 19. IX.

7458 **Cnephasia** osseana Scop. 10, 20. VI-VII.
7459 argentana Clem. 1, 10, 18, 20. VI-VII.

7468 **Argyrotoxa** bergmanniana L. 20. VII.
7469 albicomana Clem. 8, 10, 20. VII-VIII.
7471 curvilana Kft. 20. VII.

7472 **Acleris** emargana Fabr. 6, 10, 18, 20. VIII-IX (11).
7473 maccana Tr. 10, 20. VIII-V.
7473a fishiana Fern. 8, 10, 12. VIII-IV.
7475 nigrolinea ferruginiguttata Fern. 10, 21. IX-V.
7476 maximana B. & B. 10. IX-V.
7477 caliginosana Wlk. 10, 20. X-IV.
7478 latifascia Haw. 10. VIII-IX.
7480 oxycoccana Pack. 10. IX-VI.
7481 variana Fern. 10, 15, 19-21. VII.
7484 hastiana L. 8, 10, 20. IX-V.
7485 celiana Rob. 10. IX-IV.
" albilineana Kft. 8, 10. X-V.
7486 pulverosana Wlk. 16, 20. X.
7490 robinsoniana Forbes. 9, 10, 16. X-V.
7493 brittana Kft. 19, 20. VIII-X.
7494 fragariana Kft. 10. IX.
7495 inana Rob. 10. VIII-IX.
7498 scabrana D. & S. 7, 10. IX-V.
7499 lipsiana D. & S. 7, 10, IX-V.
7500 hudsoniana Wlk. 10, 20, 21. X-V.
7501 bowmanana McD. 8, 10. IX-V.

### TORTRICIDAE—*Concluded*

7502 minuta Rob. 20. VII.
" cinderella Riley. 20. V.
7503 logiana L. 7, 9, 10, 19. IX-V.
" trisignana Rob. 10. VIII-V.
7504 nivisellana Wlshm. 8, 10. X-V.
7505 cervinana Fern. 10. VI-VIII.
7508 braunana McD. 9-10. V.
7511 forbesana McD. 10. VI-VII.
7512 fuscana B. & Bsk. 7, 8, 10, 16. VIII-V.
7514 semiannula Rob. 10, 19. VIII-V.
7515 gallicolana Clem. 10. V-VI.
" heindelana Fern. 10. V-VI.
7516 cornana McD. 10. VIII-V.

### PHALONIIDAE

7530 **Phalonia** deutschiana Zett. 20. VI-VII.
7542 angulatana Rob. 10. VI-VII.
7608 **Pharmacis** vitellinana Zell. 8, 10. VI-VII.
7610 **Hysterosia** fulviplicana Wlshm. 10, 19, 20. VII.
7611 aureoalbida Wlshm. 18, 20. VI.
7613 waracana Kft. 10. VI.
7621 baracana Busck. 10, 20. VII.

### CARPOSINIDAE

7624 **Bondia** crescentella Wlshm. 10. V.
7625 **Carposina** ottawana Kft. 10. VI.
7628 comonana Kft. 10. V-VI.

### COSSIDAE

7666 **Acossus** centerensis Lint. 6, 10. VII.
7667 populi Wlk. 6, 7, 10, 18, 20. VI-VII.
7670 **Prionoxystus** robiniae Peck. 5, 10. VI-VII.

## Superfamily GELECHIOIDEA

### COSMOPTERYGIDAE

7696 **Batrachedra** praeangusta Haw. 10. IV-V.
7738 **Cyphophora** tricristatella Cham. 10, 18. VI-VII.
7743 **Walshia** amorphella Clem. 2, 10. VI.
7746 **Mompha** albopalpella Cham. 10, 18. VII.
7755 claudiella Kft. 10. VII.
7758 unifasciella Cham. 10. IV-X.

### EPERMENIIDAE

7770 **Epermenia** infracta Braun. 20. VI-VII.

### GELECHIIDAE (1)

7818 **Aristotelia** rubidella Clem. 18. VI.
7823 fungivorella Clem. 10, 20. VII-IX.
7834 roseosuffusella Clem. 8. VII.
7835 devexella Braun. 18. VII.
7854 **Chrysopora** lingulacella Clem. 10. VII.
7867 **Evippe** prunifoliella Cham. 10. V.
7886 **Recurvaria** milleri Busck. 19, 20. VII.
7893 gibsonella Kft. 10. VII-VIII.

## GELECHIIDAE (1)—*Concluded*

7908 **Eucordylea** atrupictella Dietz. 10. IX.

7932 **Telphusa** aethiops Westw. 18. VI.
7937 belangerella Cham. 8. VI.
7949 praefixa Braun. 18. VI.

7961 **Chionodes** metallica Braun. 10, 18. VI-VII.
7977 viduella Fabr. 10, 20. V-VI.
7980 lugubrella Fabr. 10, 20. VI-VII.
8005 continuella Zell. 10, 18, 20. VI-VIII.
8013 fondella Busck. 8, 10. V-VII.
8014 terminimaculella Kft. 10. V-VI.
8020 mediofuscella Clem. 10. V-VI.
8026 abella Busck. 10. III-VI.
8077 negundella Hein. 10. VIII-IX.
8106 fluvialella Busck. 10. V-VII.

7962 **Bryotropha** clandestina Meyr. 18. VI.

7965 **Aroga** trialbamaculella Cham. 20. VI.

7998 **Gelechia** mandella Busck. 20. VII.
8001 albisparsella Cham. 3. VII.
8064 conspersa Braun. 5, 18. VI.
8065 versutella Zell. 8, 10. VII-IX.
8120 nigrobarbata Braun. 18. VI.
8121 occlusa Braun. 18. VI-VII.
8122 permacta Braun. 18. VI-VII.

8023 **Lita** longicornis Curt. 8, 10, 19, 20. V-VI.
8025 petulans Braun. 19. VIII.
8032 variabilis Busck. 10, 20. VII-VIII.

8034 **Filatima** striatella Busck. 10. V.
8082 serotinella Busck. 10. V.
8098 abactella Clarke. 10. VI.
8103 abradescens Braun. 10, 18, 20. VII.

8153 **Gnorimoschema** gallaesolidaginis Riley. 10. VIII-IX.
8156 gallaeasteriella Kell. 8, 10. VI-VIII.
8160 petrella Busck. 20. VII.
8168 miscitatella Clarke. 10. VIII.
8180 ochreostrigella Cham. 20. VII.
8182 triocellella Cham. 18. VI.
8186 radiatella Busck. 18. VII.

8219 **Phthorimaea** chenopodiella Busck. 10. V-VII.

8272 **Compsolechia** niveopulvella Cham. 10, 18, 19. VII-VIII.

8285 **Thelyasceta** nonstrigella Cham. 18. VI.

8288 **Anarsia** lineatella Zell. 10. X.

8314 **Trichotaphe** fernaldella Busck. 10, 20. V-VI.
8322 setosella Clem. 10. V-VIII.
8329 leuconotella Busck. 10. VII-VIII.
8331 levisella Fyles. 10, 18. VI-VII.

8332 **Oegoconia** quadripuncta Haw. 8. VI.

## OECOPHORIDAE (8)

8440 **Agnopterix** fulva Wlshm. 6, 10. VIII.
8451 gelidella Busck. 10, 20. VII-VIII.
8431 rosaciliella Busck. 7, 10. IV.
8418 pallidella Busck. 10. X.
8413 argillacea Wlshm. 8, 10, 12, 20, 21. IV-V, IX-X.
8420 flavicomella Engel. 10. VII-VIII.

8433 **Martyrhilda** canella Busck. 18. VI-VII.
8419 nivalis Braun. 19, 20. VII-VIII.
8435 klamathiana Wlshm. 20. IX.
8434 sciadopa Meyr. 8, 10, 12, 18, 21. IV-VI, IX-X.

8464 **Bibarrambla** allenella Wlshm. 10. VI-VII.

### OECOPHORIDAE (8)—*Concluded*

8459 **Semioscopis** packardella Clem. 7, 10. IV-V.
8460 inornata Wlshm. 6-8, 10, 19, 21. IV-VI.
8461 megamicrella Dyar. 10. IV-V.
8463 aurorella Dyar. 8, 10. IV-V.

8393 **Depressaria** alienella Busck. 10, 20. VIII, IX.
8396 leptotaeniae Clarke. 18. VII.
8405 grotella Rob. 10. VIII-IX.
8406 betulella Busck. 10, 19. VIII.

8365 **Schiffermulleria** quadrimaculella Cham. 10, 18. VI-VII.

8370 **Chambersia** haydenella Cham. 18. VII.

### ETHMIIDAE

8390 **Eumeyrickia** trimaculella Fitch. 10. VI.

8367 **Ethmia** coloradella Wlshm. 10, 18, 20. VI-VII.
8612 monticola Wlshm. 6. VI.

## Superfamily YPONOMEUTOIDEA

### GLYPHIPTERYGIDAE

8643 **Anthophila** fabriciana L. 18. VI.
" alpinella Busck. 18. VI.

8645 **Allononyma** vicarialis Zell. 8, 10, 19, 20. IV-V, VIII-X.
8646 diana Hbn. 21.

8652 **Choreutis** pernivalis Braun. 10. VI.
8663 onustana Wlk. 18. VI.
8664 balsamorrhizella Busck. 18. VII.
8666 occidentella Dyar. 10, 18, 20. VI-VII.
8669 leucobasis Fern. 20. V-VI, IX.
N/R myllerana Fab. 10. VII.

8680 **Ellabella** editha Busck. 18. VI.

### AEGERIIDAE (3)

8684 **Bembecia** marginata Harr. 5, 10, 20. VII-VIII.

8708 **Ramosia** tipuliformis Clerck. 3.

8769 **Podosesia** syringae fraxini Lug. 6. VII.

8789 **Albuna** pyramidalis Wlk. 6, 7, 10, 18-20. VI-VII.
" coloradensis Hy.-Ed. 10. VI.

8796 **Vitacea** polistiformis Harr. 6, 18. VI-VIII.

### PLUTELLIDAE

8842 **Trachoma** falciferella Wlshm. 8, 10. IV, IX-X.
8844 senex Wlshm. 10, 16, 19. VIII.

8845 **Harpipteryx** dentiferella frustrella Wlshm. 6, 10, 19. VII-IX.
" canariella Wlshm. 10, 19. VII-IX.

8863 **Cerostoma** dorsimaculella Kft. 10. VII.

8870 **Plutella** porrectella L. 10, 18. VI-VII.
8871 poulella Busck. 20. IX.
8875 interrupta Wlshm. 10. V.
8878 maculipennis Curt. 10. VII-X.

### YPONOMEUTIDAE

8890 **Argyresthia** goedartella L. 10. VII.
8891 pygmaeella Hbn. 10, 18. VII.
8893 oreasella Clem. 10, 18. VII-VIII.
8902 monochromella Busck. 18. VI.
8903 conjugella Zell. 18. VII.
8921 **Zelleria** gracilariella Busck. 10. IV-V.
8925 **Swammerdamia** cuprescens Braun. 10. VI-VII.
8927 **Xyrosaris** celastrustella Kft. 20. IX.

### SCYTHRIDAE

8956 **Scythris** ochristriata Wlshm. 18. VI.
8964 magnatella Busck. 10. VII-IX.

## Superfamily CYCNODIOIDEA

### DOUGLASIDAE

9005 **Tinagma** gigantea Braun. 18. VI.
9006 pulverilinea Braun. 18. VI.

### ELACHISTIDAE

9009 **Elachista** orestella Busck. 20. VII.
9031 aurocristata Braun. 10, 18. V-VI.

## Superfamily TINEOIDEA

### COLEOPHORIDAE

9061 **Coleophora** eleagnisella Kft. 10, 20. VI-VII.
9092 coruscipennella Wlshm. 8, 10, 20. VI-VIII.
9105 innotabilis Braun. 10. VI-VII.
9122 brunneipennis Braun. 10. VI-VII.
9130 acutipennella Wlshm. 18. VI.
9142 tenuis Wlshm. 18. VI.
9143 crinita Braun. 18. VI.

### GRACILLARIIDAE

9300 **Acrocercops** astericola F. & B. 10. VI.
9320 **Parectopa** pennsylvaniella Eng. 10. VII.
9325 albicostella Braun. 10. VII.
9356 **Gracillaria** cornusella Ely. 10. V-VII.
9374 negundella Cham. 10. IX-X.
9382 acerifoliella Cham. 10. VI-VII, IX.
9388 invariabilis Braun. 10. IV-VI, IX-X.
9391 alnivorella pulchella Clem. 10. IX-X.
9394 murtfeldtella Busck. 18. VI.

### OPOSTEGIDAE

9406 **Opostega** cretea Meyr. 10. VII.

### LYONETIIDAE

9448.1 **Bucculatrix** canadensisella Cham. 10. VI.

### PSYCHIDAE

9532 **Hyaloscotes** fragmentella Hy.-Edw. 18. VI.

### TINEIDAE

9588 **Myrmecozela** coloradella Dietz. 18. VI.

9628 **Elatobia** martinella Wlk. 18. VI.

9631 **Monopis** biflavimaculella Clem. 10. VII.
9633 monachella Hbn. 10. IX.

9641 **Tinea** misella Zell. 10. VII.
9643 fuscipunctella Haw. 10. VII-VIII.
9644 irrepta Braun. 3, 20. VII.
9652 grumella Zell. 10. VI-VII.
9653 pellionella L. 10. VII.
9670 roburella Dietz. 10. VI.
9686 granella L. 10. VIII-IX.

9695 **Tineola** biselliella Hum. 10. I-XII.

## Superfamily INCURVARIOIDEA

### INCURVARIIDAE

9796 **Lampronia** variata Braun. 18. VI-VII.
9800 piperella Busck. 18. VI.
9801 aenescens Wlshm. 18. VI.
9802 politella Wlshm. 18. VI-VII.
9803 sublustris Braun. 8, 10, 18. VI.
9804 obscuromaculata Braun. 18. VI.

9806 **Greya** humilis Wlshm. 10. V.
9807 subalba Braun. 18. VI.

9815 **Chalceopla** cockerelli Busck. 18

### PRODOXIDAE

9823 **Prodoxus** quinquepunctellus Cham. 2. VI-VII.

9834 **Tegeticula** alba Zeller. 2. VI-VII.

### ADELIDAE

9838 **Nemetois** bellela Wlk. 10, 20, 21. VI.

9844 **Adela** purpurea Wlk. 6, 7, 10. V.

## Suborder JUGATAE

### HEPIALIDAE

9858 **Sthenopis** argenteomaculatus Harris. 6. VII.
9859 purpurascens Pack. 6-8, 10. VII-VIII.
9860 quadriguttatus Grt. 6-8, 10. VII.

9863 **Hepialus** hyperboreus Moesch. 10, 21. VII.
9865 roseicaput N. & D. 19, 21. VIII.
9869 novigannus B. & B. 6, 10, 18, 19, 21. VII-X.
" mackiei B. & B. 6, 10, 18, 19, 21. VII-X.
9871 gracilis Grt. 10. VII.

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KENNETH BOWMAN.

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